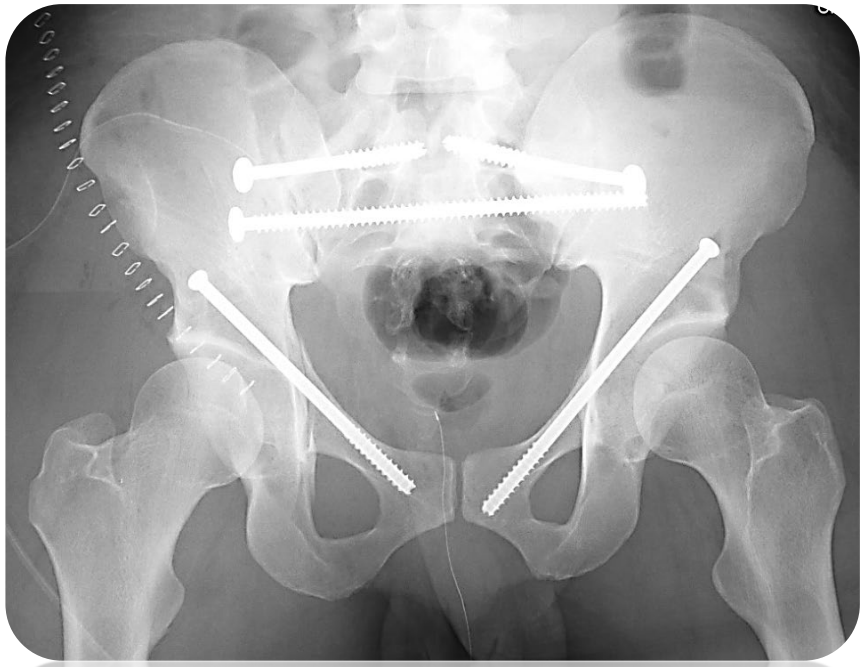
Definitive Treatment of Pelvic Ring Injuries



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OTA

Objectives

- **Describe classification systems in regards to:**
  - **Stability**
  - **Treatment**
- **Define classically operative and non-operative pelvic ring injuries**
- **Be aware of controversy in determining proper management**
- **Explain treatment strategies:**
  - **Posterior pelvic ring**
  - **Anterior pelvic ring**
- **Describe outcomes**

Treatment depends entirely on the *stability* of the pelvic ring

But…

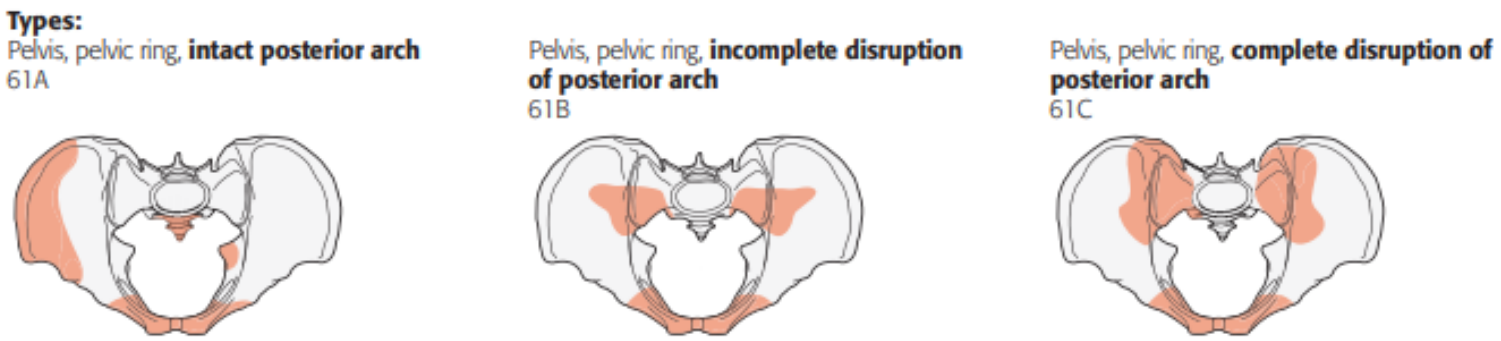
What *is* stability?

Stability

- Pelvic stability is the ability to withstand physiologic loads

- Loads from the trunk are distributed from the lumbar spine through the posterior pelvic ring to the bilateral acetabulae

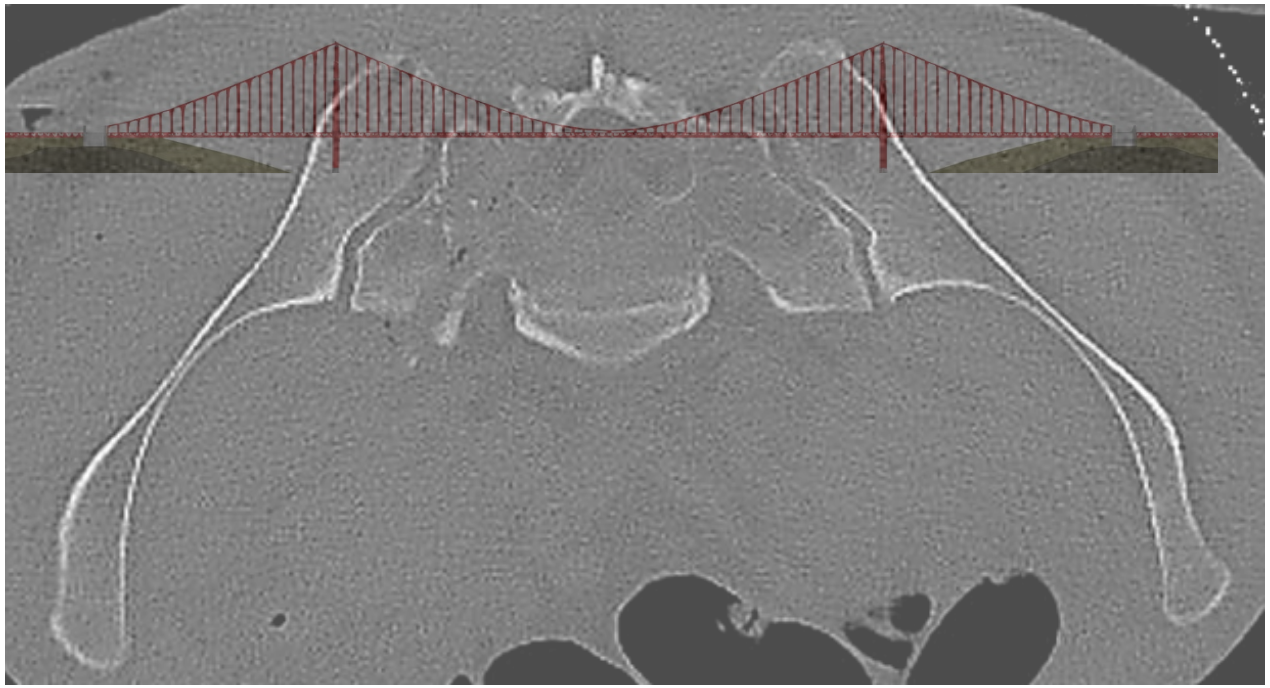
- Stability is therefore related to the degree of posterior ring injury:



Pelvic Ring. *J Orthop Trauma*. Jan 2018;32 Suppl 1:S71-S76.

Stability

- Posterior pelvic stability is analogous to a suspension bridge, with the posterior sacroiliac ligaments forming the cables and the posterior ilium and sacrum acting as towers.



Stability – Axially Stable Fractures

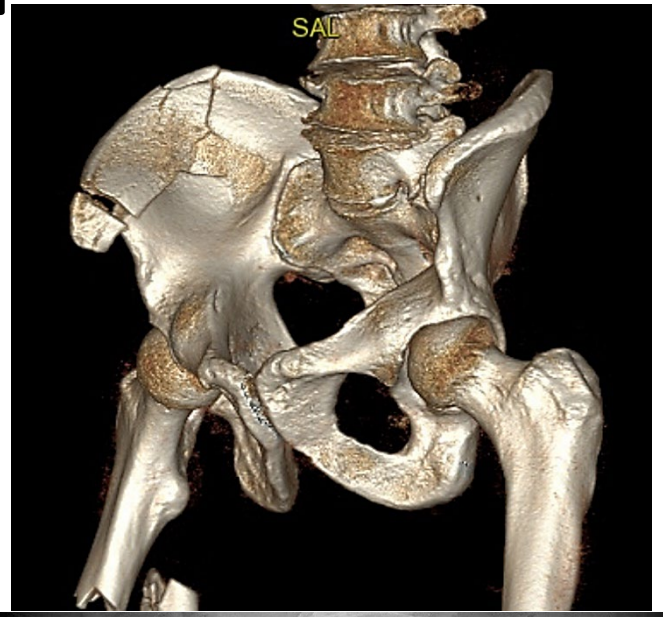
- Refer to “Radiographic Evaluation and Classification of Pelvic Ring Injuries” lecture
- Tile “A” fractures and AO/OTA 61A fractures are inherently stable in terms of the posterior pelvic ring:

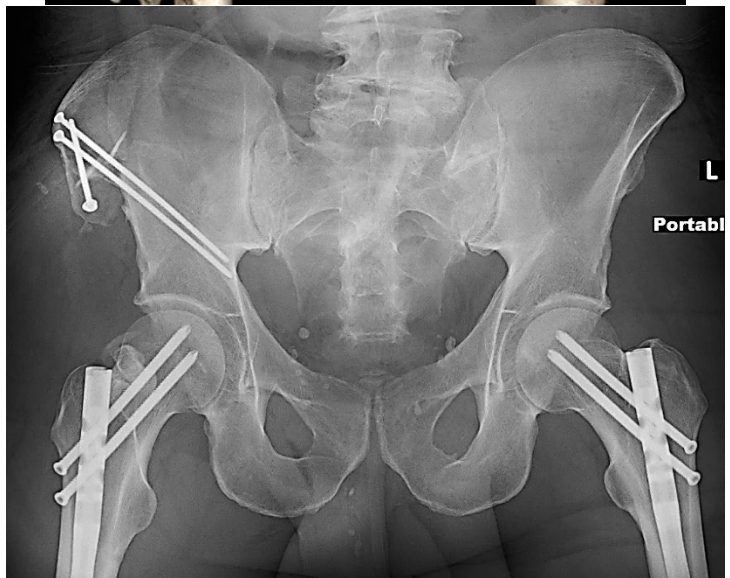
- Generally, these are treated non-operatively…

Stable Pelvic Ring ≠ Non-operative Treatment

Operative treatment may be considered when:

1) Patient is polytraumatized
2) Fracture pain severely limits mobilization
3) Non-operative treatment has failed





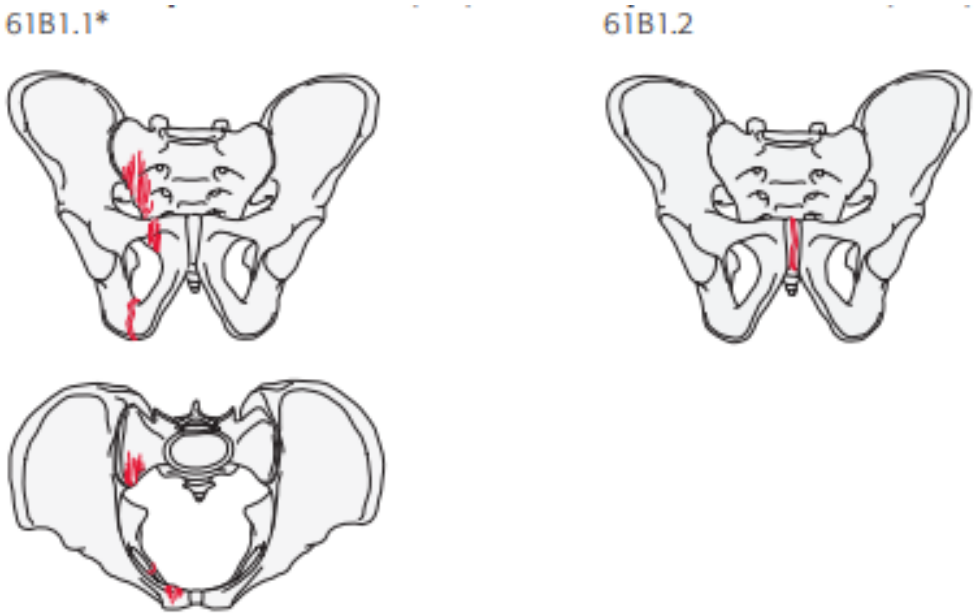
Courtesy of Conor Kleweno, MD

Stability – Rotationally Unstable Fractures

- Tile “B” and AO/OTA 61B are rotationally unstable with incomplete posterior pelvic ring injuries:

- Controversy exists as to treatment method in this category

- Many 61B1 injuries can be treated non-operatively, however…



Stability – Rotationally Unstable Fractures

- Bruce et al. (JOT 2010) studied 117 lateral compression pelvis fractures (AO/OTA 61B) which were managed non-operatively.
- Distinguishing features of the pelvis fractures were correlated with late radiographic fracture displacement.

TABLE 1. Rates of Displacement Observed With Individual Pelvic Fracture Characteristics*

Characteristic	Total Number	No. Displaced	Rate of Displacement
No rami fracture	5	0	0%
Unilateral rami fracture	68	6	8.8%
Bilateral rami fracture	44	17	39%
Incomplete sacral fracture	76	2	2.6%
Complete sacral fracture	41	21	50%

*Rami fractures include ipsilateral and contralateral injuries to the sacrum.

TABLE 2. Rates of Displacement Observed With Combined Pelvic Fracture Characteristics*

Characteristic	Total Number	Number of Displaced	Rate of Displacement
Incomplete sacral fracture + none or unilateral rami fracture	54	0	0%
Incomplete sacral fracture + bilateral rami fractures	22	2	9%
Complete sacral fracture + no rami fracture	2	0	0%
Complete sacral fracture + unilateral rami fracture	17	6	33%
Complete sacral fracture + bilateral rami fractures	22	15	68%

*Rami fractures include ipsilateral and contralateral injuries to the sacrum.

Bruce B, Reilly M, Sims S. OTA highlight paper predicting future displacement of nonoperatively managed lateral compression sacral fractures: can it be done? *J Orthop Trauma*. Sep 2011;25(9):523-7.

When in doubt → Obtain more data!

- Sagi et al. (JOT 2011) performed an examination under anesthesia (EUA) for 68 patients with AO/OTA-61B injuries.
- All patients received a standardized 15 fluoroscopic view EUA.

- **50%** of APC-1 injuries were found to be occult APC-2 injuries which necessitated surgical intervention.
- **37%** of LC-1 injuries were found to be unstable and were treated with surgical fixation.

Sagi HC, Coniglione FM, Stanford JH. Examination under anesthetic for occult pelvic ring instability. *J Orthop Trauma*. Sep 2011;25(9):529-36.

Examination Under Anesthesia

- https://otaonline.org/video-library/45037/annual-meeting-and-conferences/multimedia/18524822/hip-dislocations-and-pelvic-injuries-eua-and-need

When in doubt → Obtain more data!

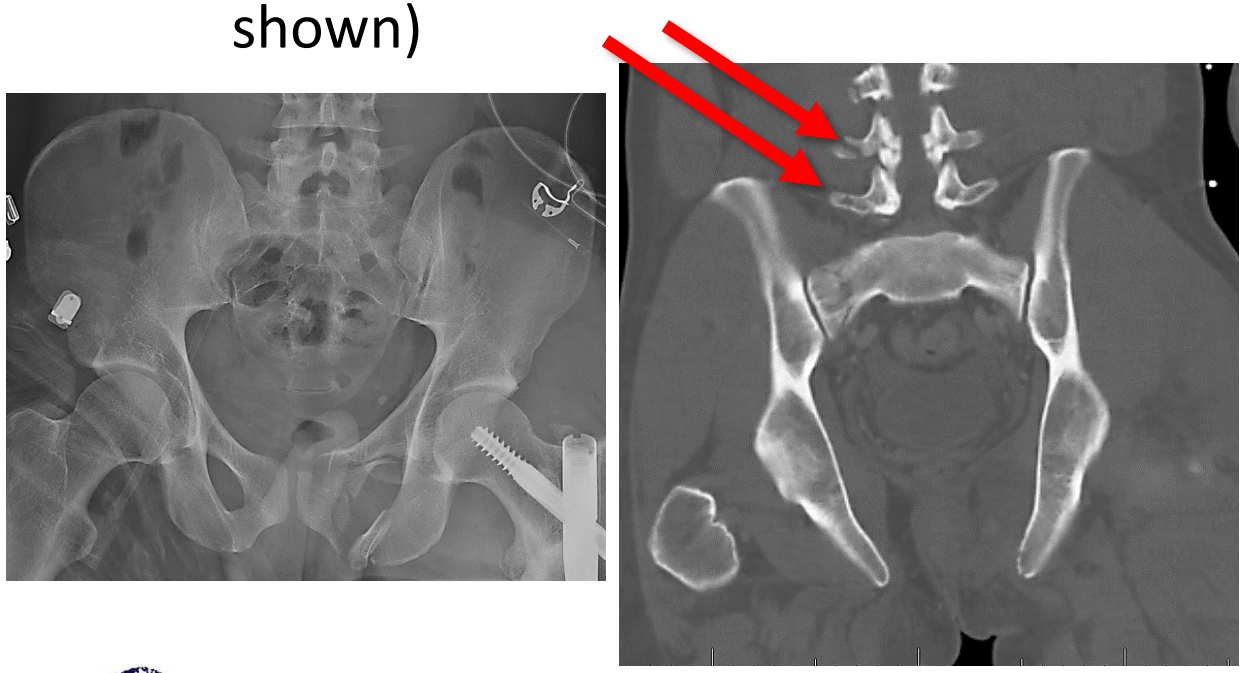
- Sigel et al. (JBJS 2008) studied 38 injured patients with pelvic pain in a clinic setting.
- Standard pelvic x-rays (AP, inlet, outlet) as well as single leg stance films (“flamingo” views) were obtained.

- **25/38** patients were found to have an unstable pelvic ring injury

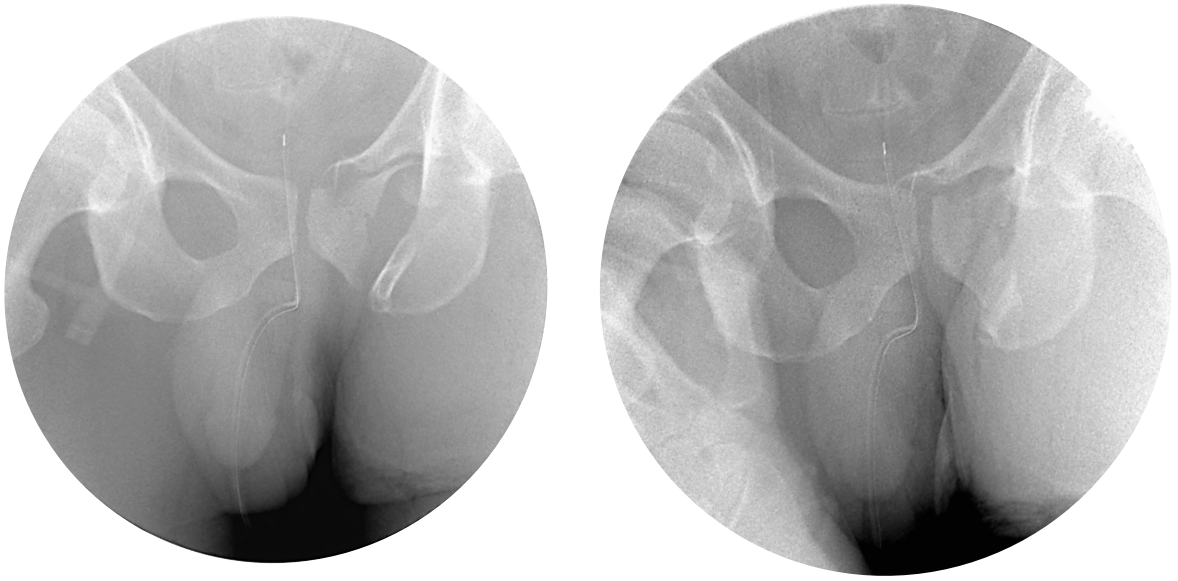
Siegel J, Templeman DC, Tornetta P. Single-leg-stance radiographs in the diagnosis of pelvic instability. *J Bone Joint Surg Am*. Oct 2008;90(10):2119-25.

When in doubt → Obtain more data!

- Assess for subtleties in pre-operative imaging:
  1) L5 transverse process fracture
  2) Avulsion fractures of ischial spine (not shown)



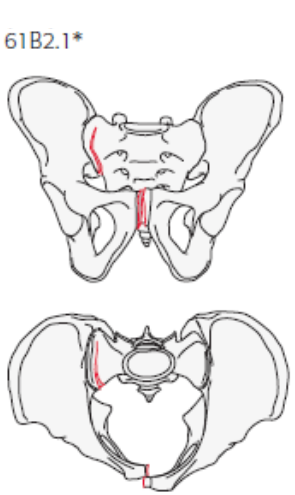
Pre-operative imaging

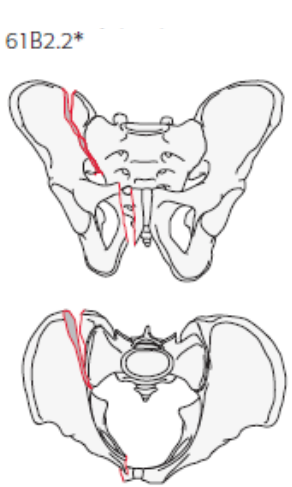


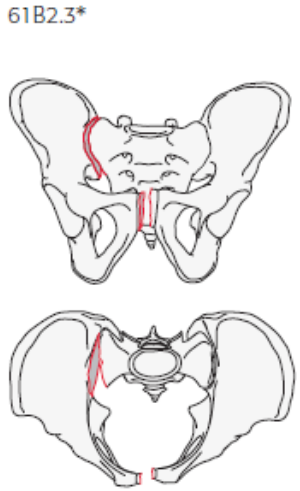
Examination under anesthesia

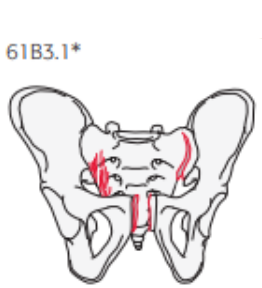
Stability – Rotationally Unstable Fractures

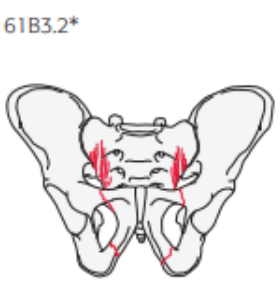
- An increased burden of injury, as shown in the later 61B classifications signifies greater pelvic instability.
- These are generally treated operatively.

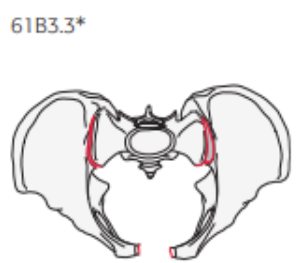












Pelvic Ring. *J Orthop Trauma*. Jan 2018;32 Suppl 1:S71-S76.

Stability – Complete Posterior Instability

- Tile “C” and AO/OTA 61C represent pelvic ring injuries with incompetent posterior structures necessitating operative intervention.

Pelvic Ring. *J Orthop Trauma*. Jan 2018;32 Suppl 1:S71-S76.

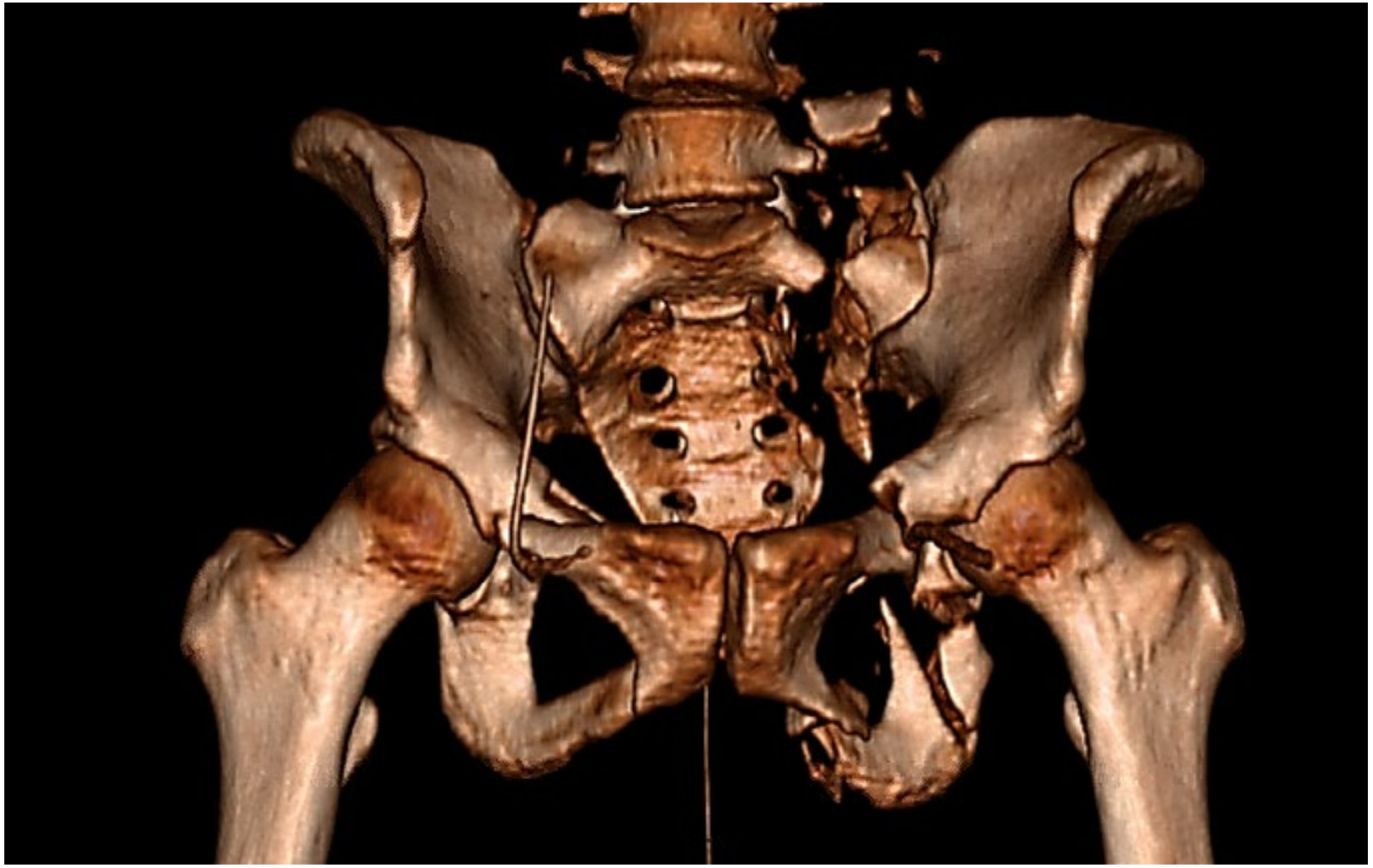
Treatment Strategy

- Ultimate treatment is dependent upon…
  - Amount of fracture displacement
  - Physiologic status of patient
  - Concurrent injuries which may preclude certain operative positions or approaches
  - Angiographic embolization which may increase infection risks of certain approaches
  - Prior abdominal surgeries (i.e. a prior hernia repair with mesh)
  - Knowledge and comfort level of the operative surgeon

Treatment Strategy, continued

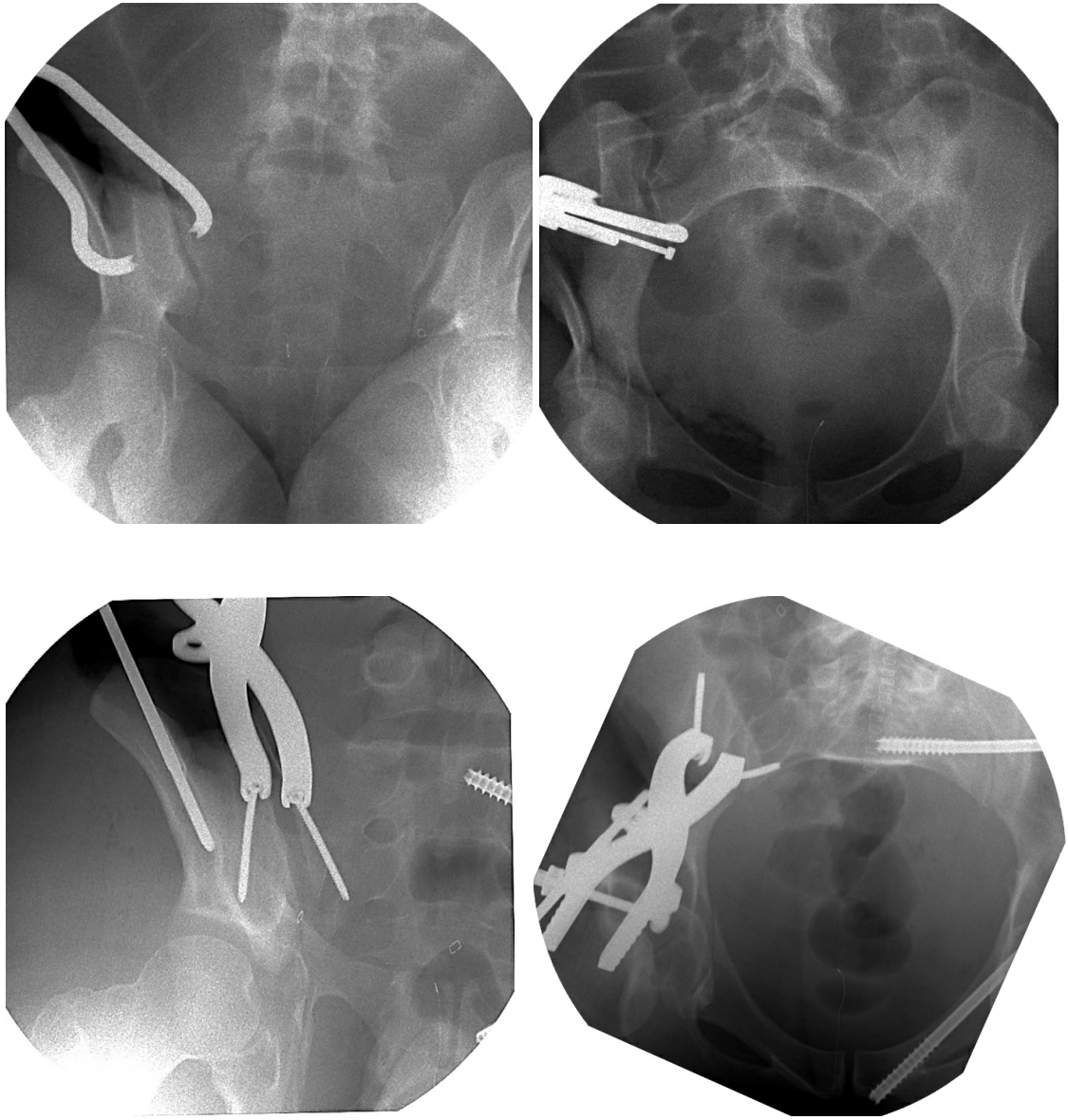
- Available operative interventions exist in a spectrum of invasiveness.
- Careful preoperative planning is essential. Use all imaging modalities available to include CT and 3D surface rendered imaging.
- The surgeon must have the ability to alter the preoperative plan should a less invasive treatment not result in an accurate reduction.

Posterior Pelvis Reduction and Fixation



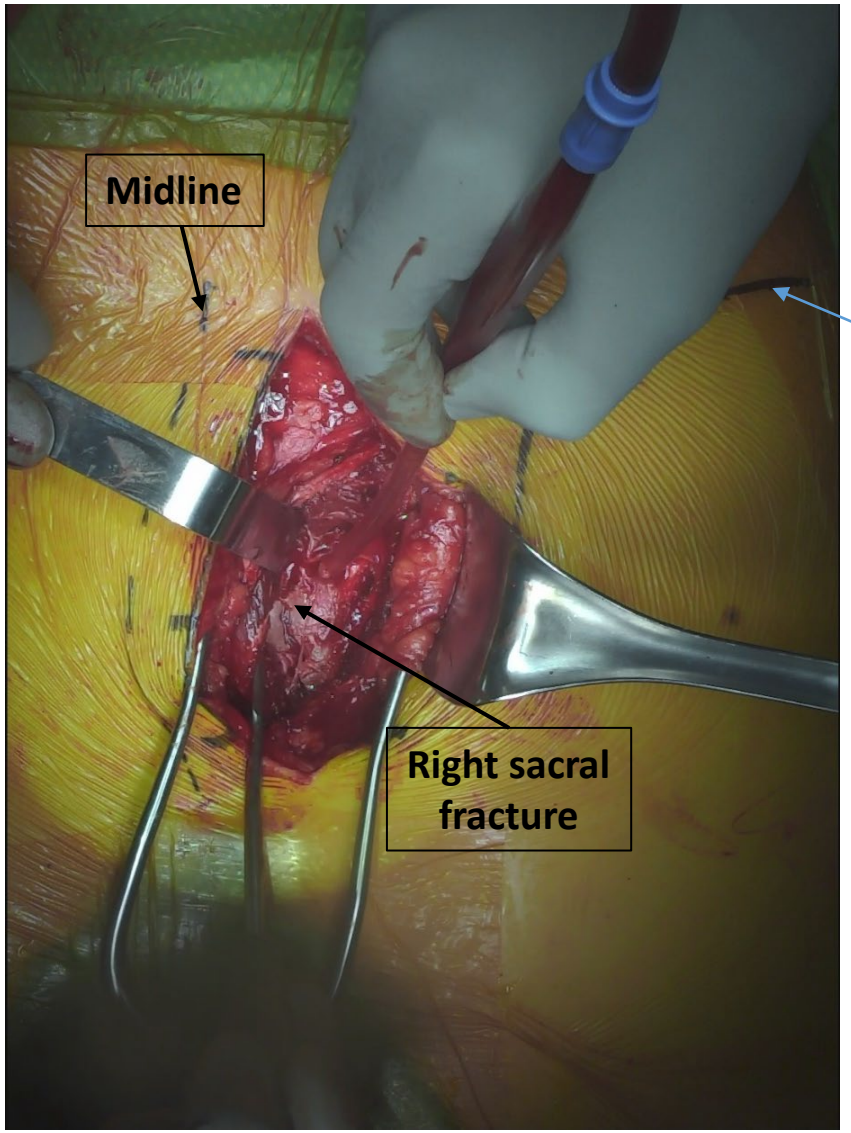
Sacroiliac Joint Reduction

- Usually reduced *indirectly* with reduction of the anterior ring.
- Can be performed open from the lateral window of an ilioinguinal approach or posteriorly through a paramedian approach.
- Clamp tine placed posterior on the ilium and about the anterior sacral ala (*top right*).
- Screw based clamp may be required (*bottom right*).



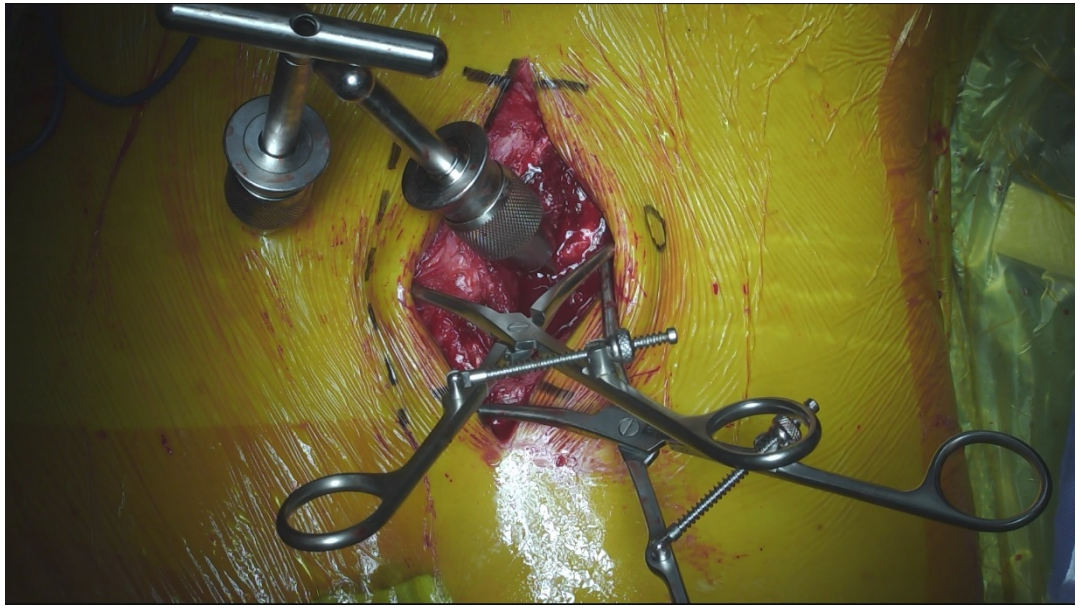
Sacral Fracture Reduction

- Generally performed *indirectly* with external fixator, universal distractor, c-clamp, or reduction frame.
- Open reduction through posterior paramedian approach.
  - Reduce with schanz pins placed in each PSIS.
  - Clamp tines placed on sacral spinous processes and PSIS.



Courtesy of Conor Kleweno, MD

Sacral Fracture Reduction



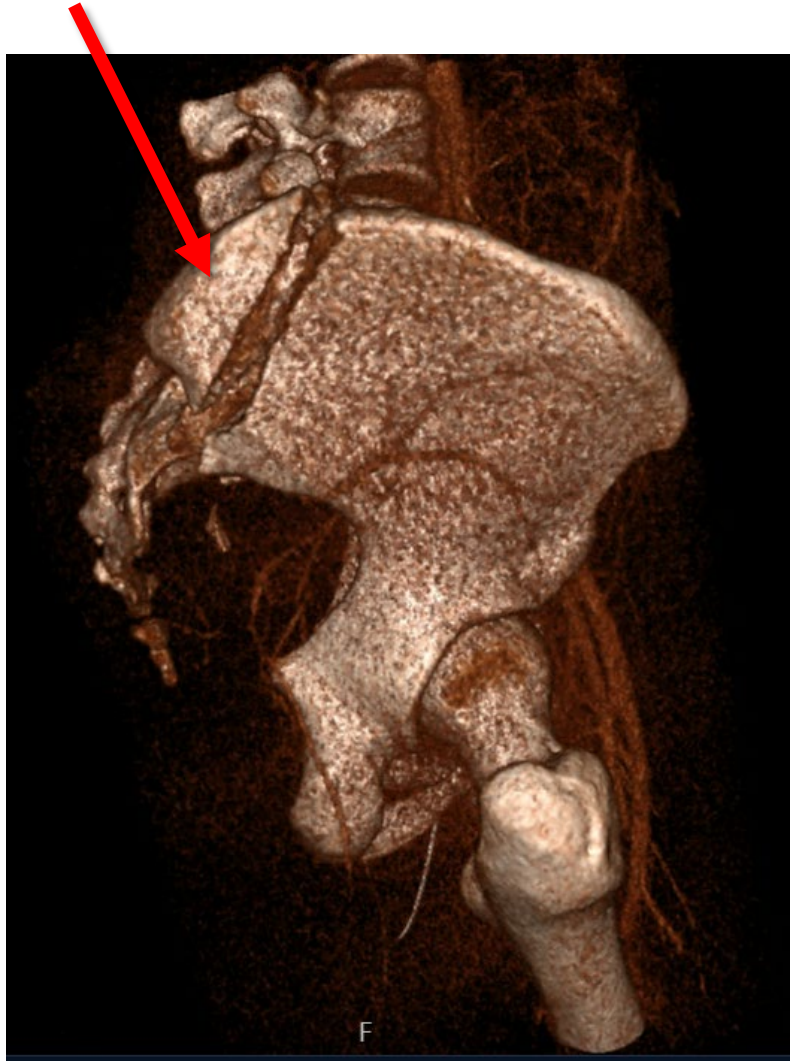
Right sided paramedian approach with T-handled chucks attached to 5.0mm schanz pins placed in each PSIS. These are used to manipulate the injured hemipelvis.

After gross reduction is achieved, fine-tuning and compression are accomplished with 2 large Weber clamps with clamp tines placed on the PSIS and sacral spinous processes. Note 1 clamp provides lateral to medial compression while the other cranial to caudal.

Courtesy of Conor Kleweno, MD

Crescent Fracture Reduction

- These injuries are fracture / dislocations of the sacroiliac joint seen in the Young-Burgess “LC-2” patterns.
- Indirect reduction is standard with traction, external/internal fixators, and/or reduction of anterior injuries.
- May be opened through a lateral window of an ilioinguinal approach for clamp placement.



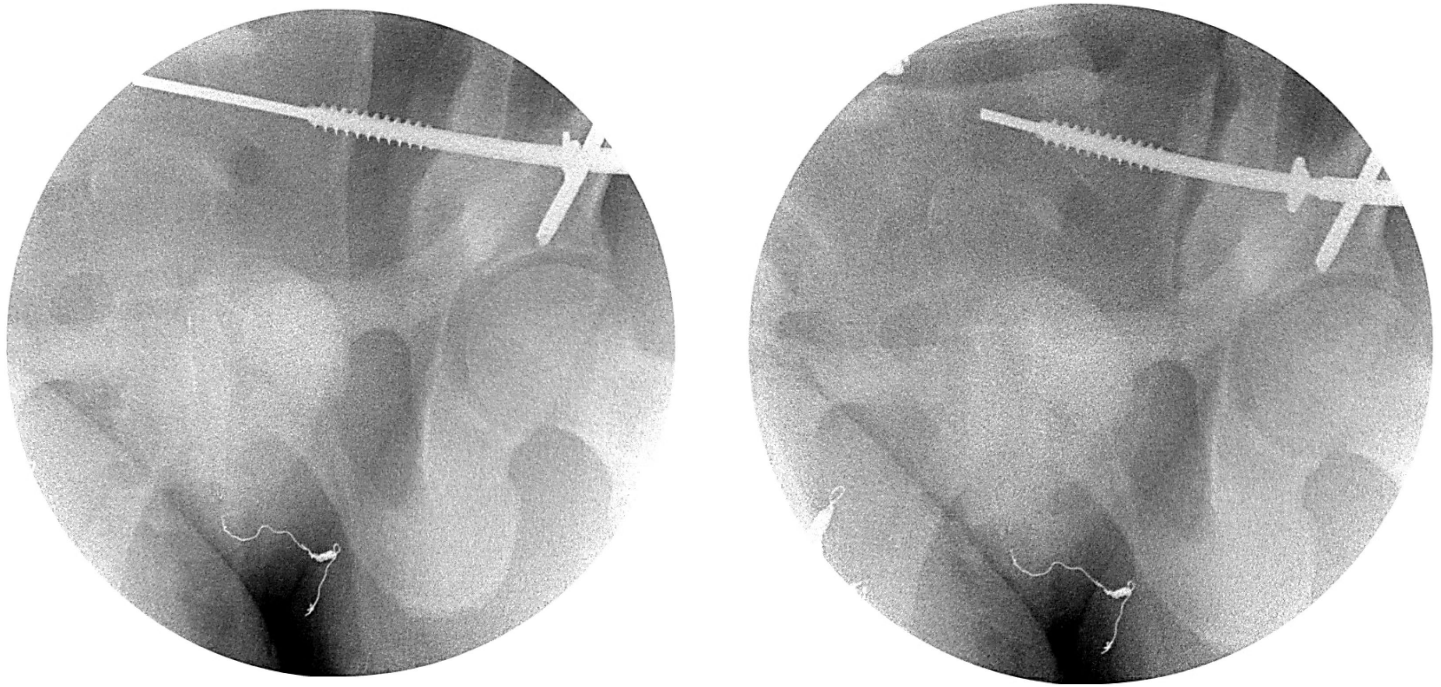
Treatment Options

I. Posterior Ring
   i. Percutaneous sacroiliac screws
   ii. Percutaneous trans-iliac, trans-sacral screws
   iii. Percutaneous lumbopelvic fixation
   iv. Open sacroiliac joint plating
   v. Open sacral plating
   vi. Lumbopelvic fusion

II. Anterior Ring
   i. External fixation
   ii. Internal-external fixation (Infix)
   iii. Percutaneous ramus screws
      a. Antegrade or retrograde
   iv. Open plating of pubic symphysis
   v. Open plating of pubic ramus

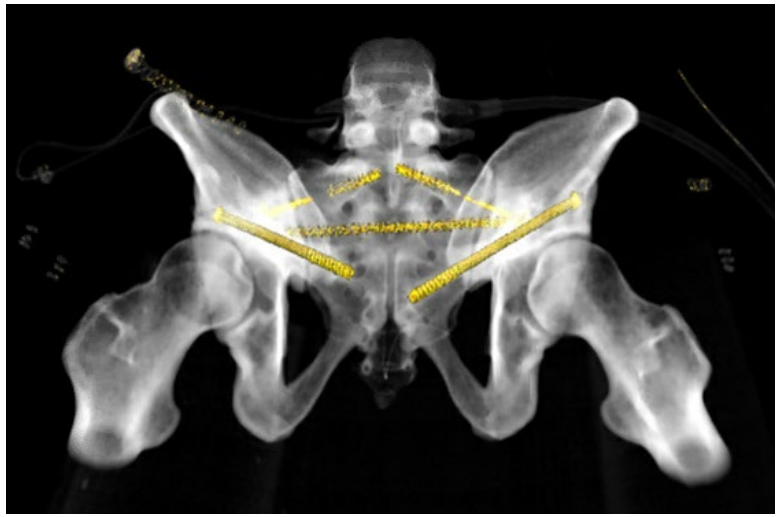
Treatment – Posterior Ring

- Percutaneous fixation
  - Minimally invasive
  - Can be used as a reduction tool, resuscitative aid (shown below), or to stabilize comminution in the setting of a sacral fracture.

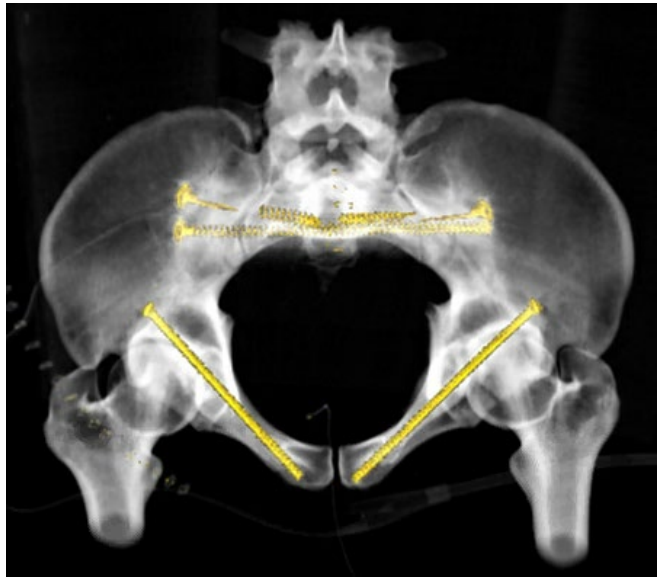


Percutaneous Iliosacral Screws

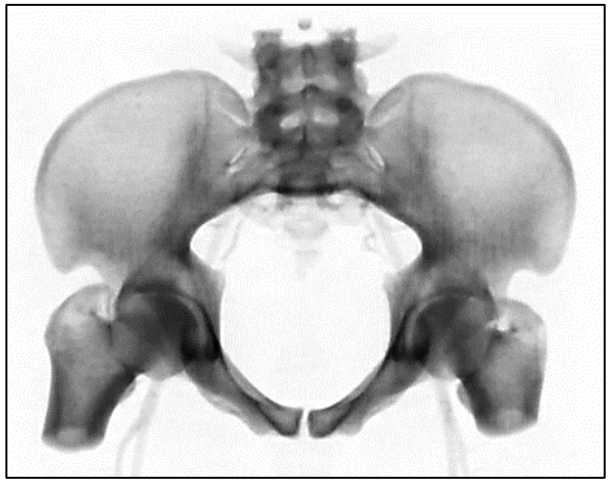
- **Sacroiliac screw (shown in upper sacral segment)**
  - Trajectory – Posterior and Caudal → Anterior and Cranial



- **Trans-iliac, trans-sacral screw (shown in second sacral segment)**
  - Trajectory – screw passes safely across 6 cortices perpendicular to the long axis of the sacrum



Iliosacral screw radiographic views

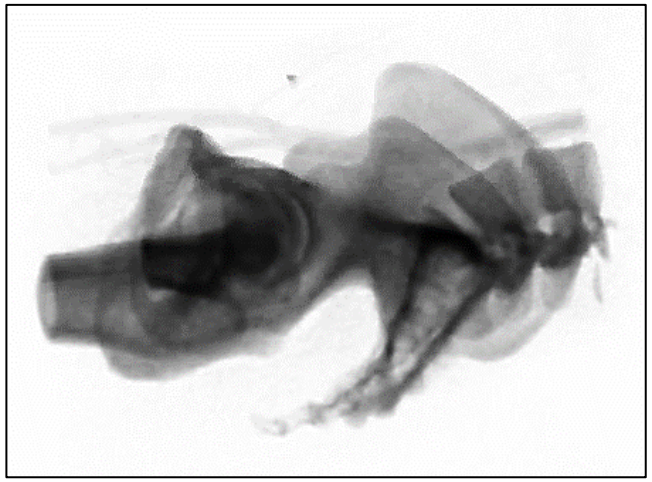


Inlet

- Bodies of S1 and S2 are overlapped.
- Will guide placement of screw in the anterior to posterior plane.

Outlet

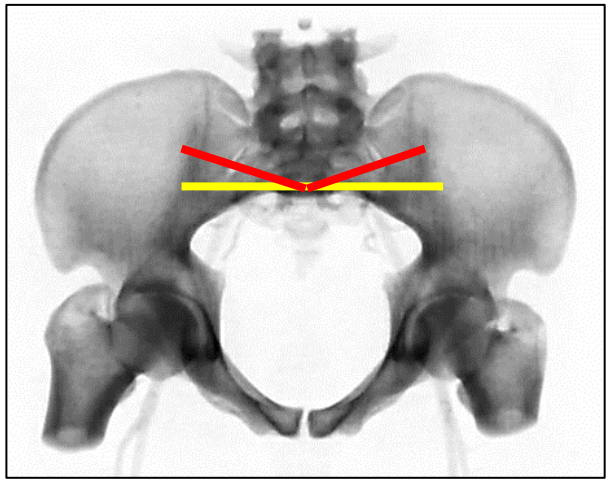
- Pubic symphysis bisects the body of S2.
- Will guide placement of screw in the cranial to caudal plane.



Sacral Lateral

- Iliac cortical densities are overlapped.
- Will determine safe screw placement when the wire/drill bit is at the level of the L5 nerve root.

Iliosacral screw radiographic views



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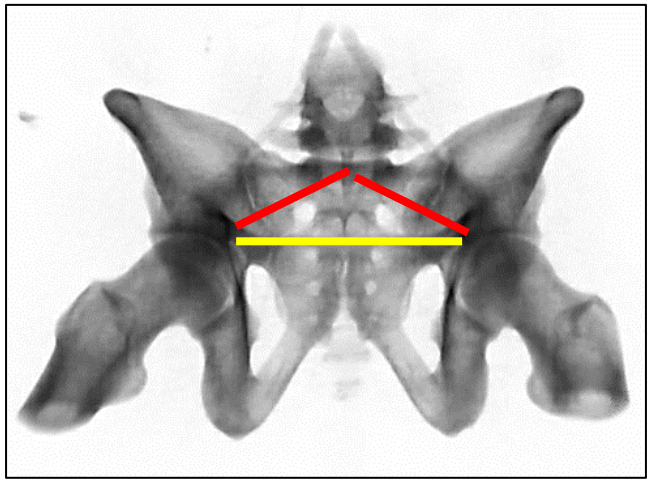

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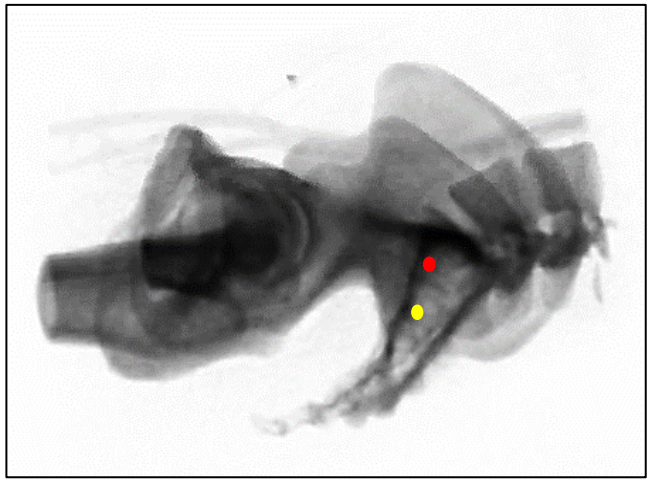

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- Will determine safe screw placement when the wire/drill bit is at the level of the L5 nerve root.

Sacral Lateral View

- Will assist in determining if the L5 nerve root is in danger of becoming damaged.
- Iliac cortical densities are the *overlap* of the true pelvis posterior to the acetabulum – this is used as a proxy for the slope of the sacral ala.
- The bilateral iliac cortical densities must be overlapped to determine screw safety.
- A wire or drill bit that is anterior to the iliac cortical density (at the level of the L5 nerve root) is too anterior and the nerve root is in danger.

Sacral Lateral View

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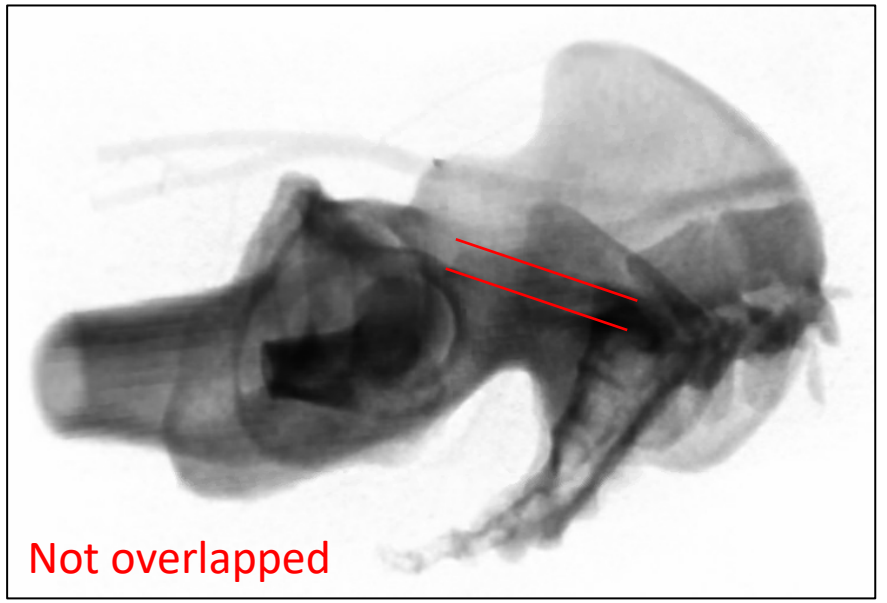
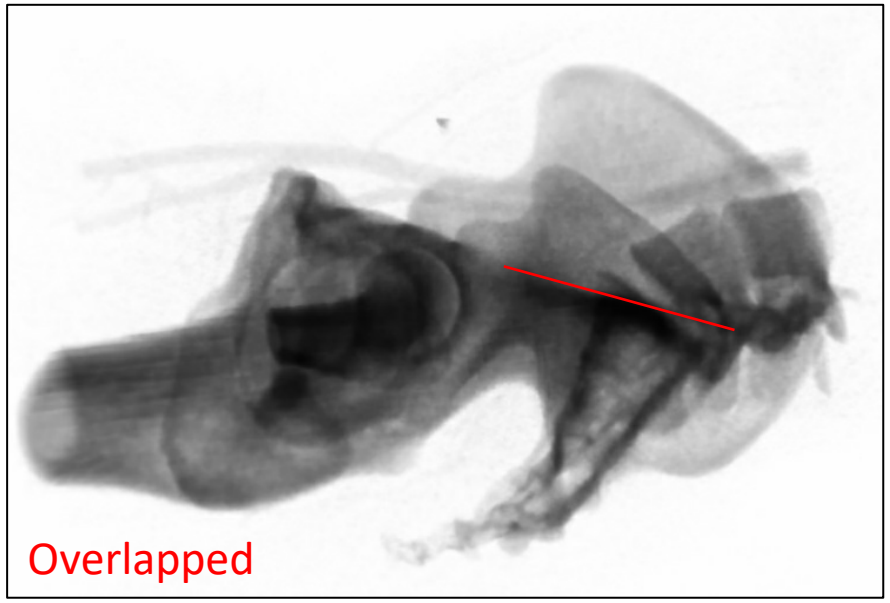
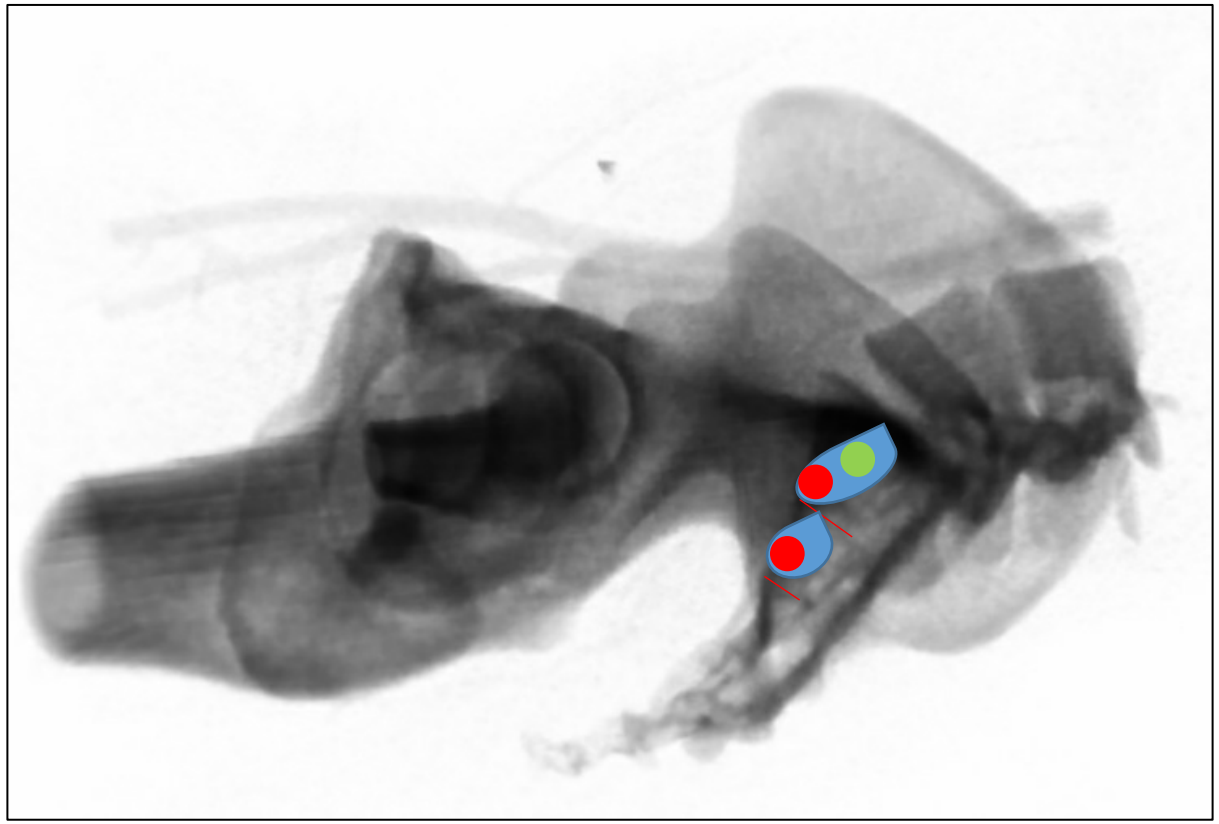




Sacral Lateral View



- Blue areas represent safe zones for screw placement. If more than one screw is to be placed in the same sacral segment, one should be **anterior** and **caudal**, while the other is **posterior** and **cranial**

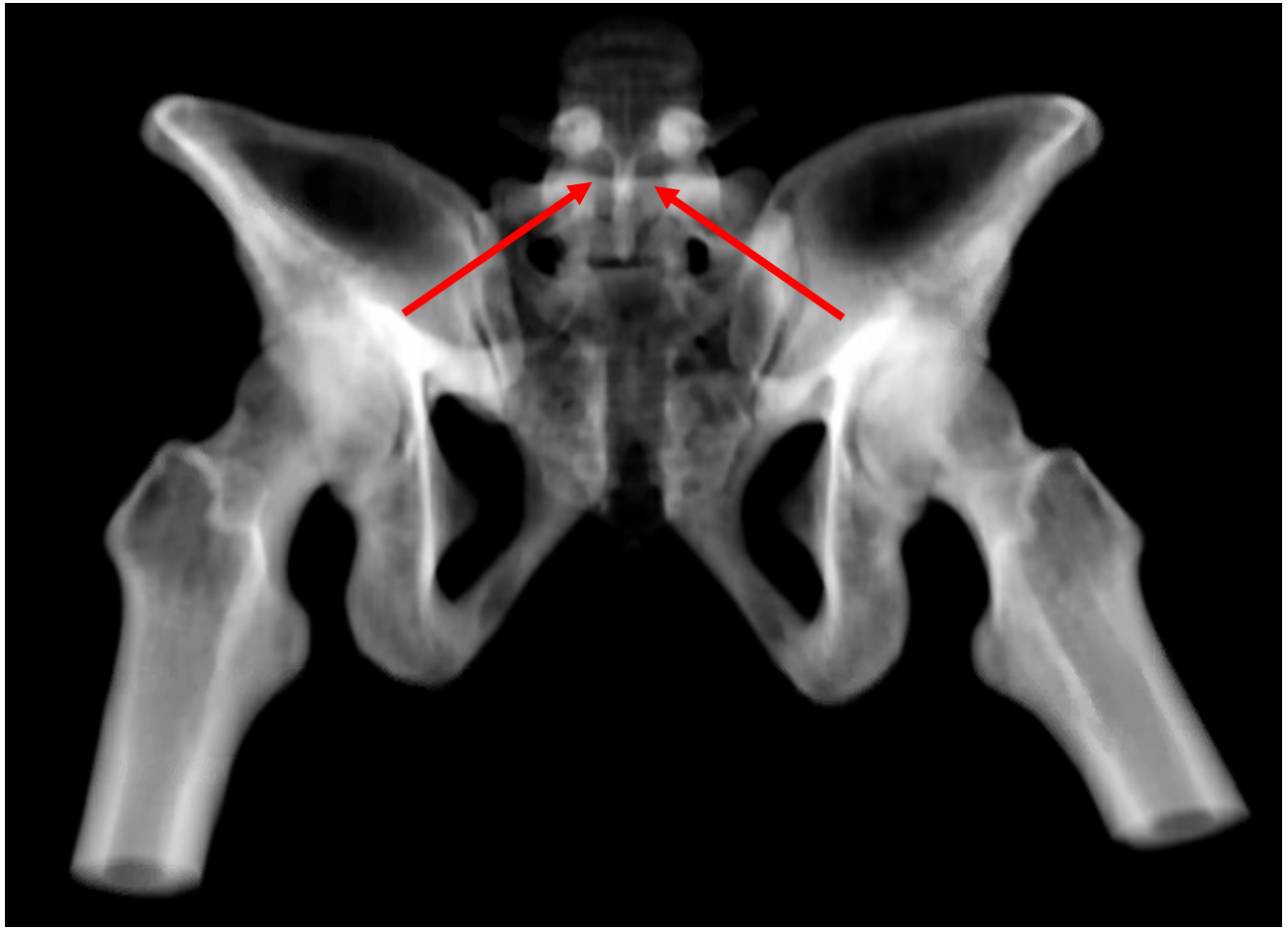
Sacral Dysmorphism

Danger

The iliac cortical density, as seen on a sacral lateral, cannot be used to determine screw safety in a dysmorphic sacrum

- Features of sacral dysmorphism:
  1) Acute upper sacral segment slope.
  2) Height of sacrum similar to that of iliac wing
  3) Mamillary processes
  4) Irregularly round shaped S1 nerve root tunnel
  5) Dorsally recessed upper sacral segment ala
  6) Residual S1 disc
  7) “Tongue-in-groove” sacroiliac joint

Sacral Dysmorphism



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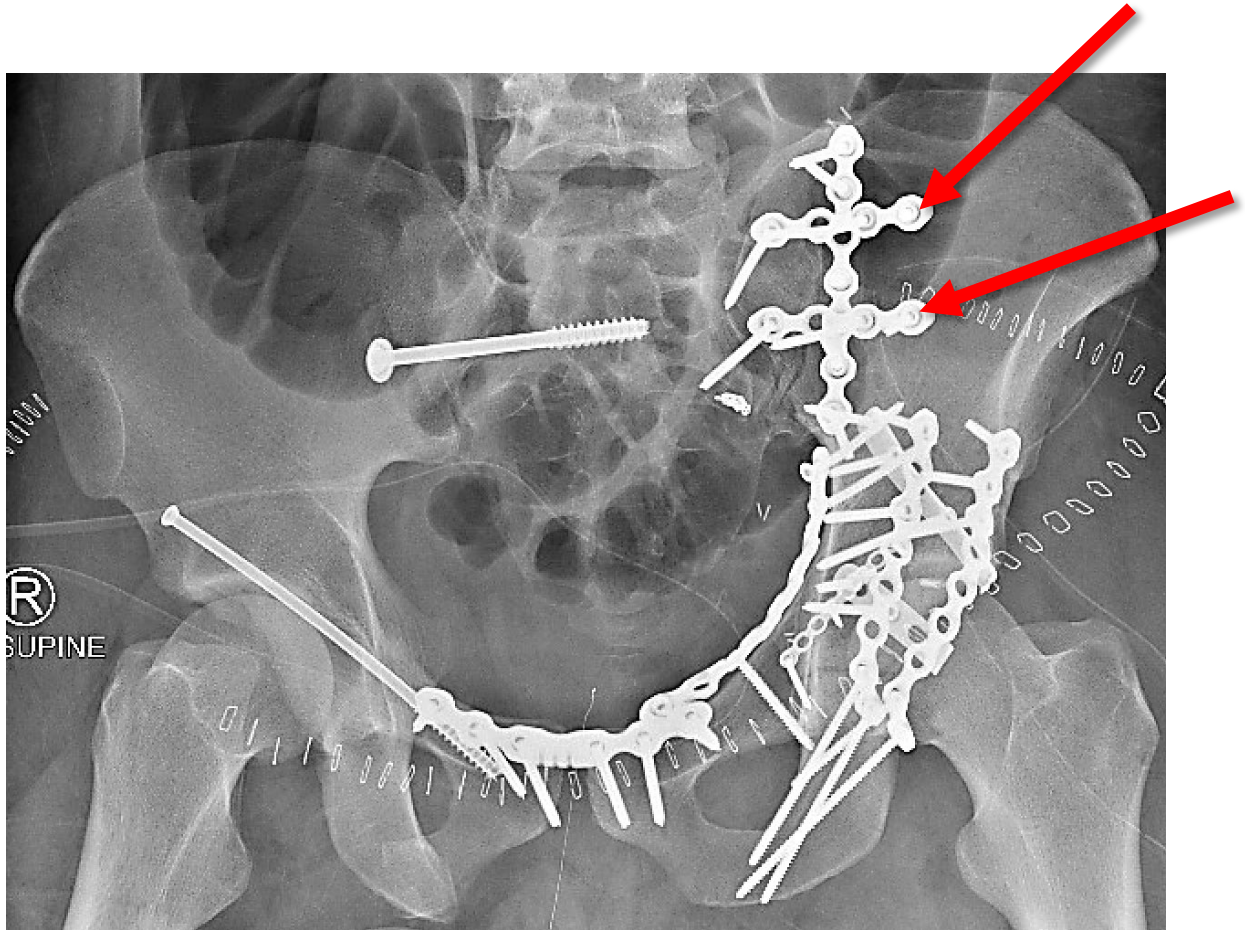
Pre-Operative Planning Iliosacral Screws

- https://otaonline.org/video-library/45036/procedures-and-techniques/multimedia/16731381/pre-operative-planning-for-percutaenous-transiliac

Sacroiliac joint plating

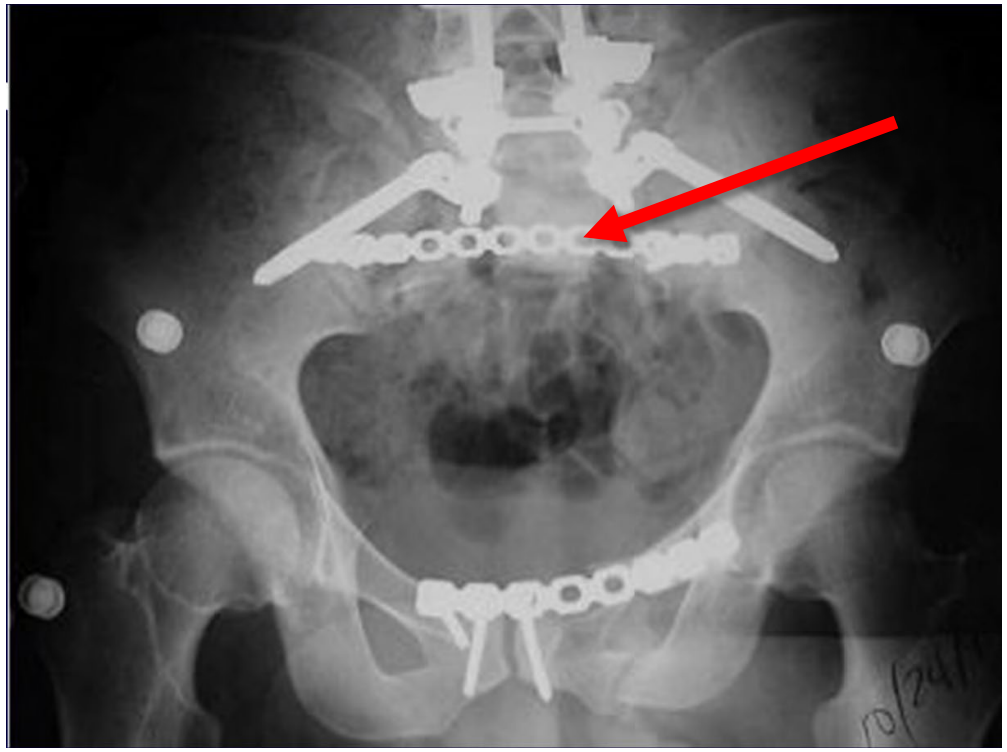
- Used when:
  - Sacroiliac joint cannot be reduced by closed means
  - Osseous fixation pathways do not allow safe screw placement

- Performed through lateral window of ilioinguinal approach
  - Can add inguinal ligament peel or ASIS osteotomy to improve visualization



Left sided SI joint plating shown by red arrows. This was necessary due to the crescent fracture propagating into the area of any iliosacral screw placement. Courtesy of Robert Wojahn, MD.

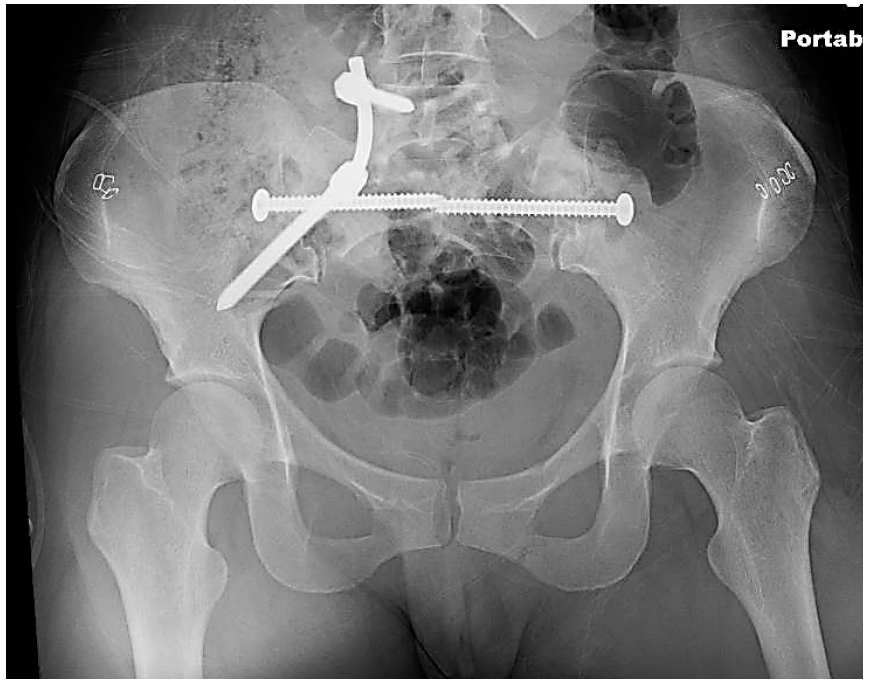
Sacral Fracture Plating



- Used to restore posterior tension (refer to suspension bridge analogy)
- Placed through bilateral paramedian approaches
- Useful when existing hardware precludes iliosacral screw placement (shown) or no safe sacral osseous fixation pathway exists.

Lumbopelvic Instrumentation

- Refer to “Lumbopelvic Fractures and Fixation” lecture.
- Consider lumbopelvic ***fusion*** (*above right*) if sacral nerve roots require decompression or if no osseous fixation pathways exist for safe iliosacral screw placement.
- Consider lumbopelvic ***fixation*** (*below right*) for highly comminuted sacral fractures and/or those with vertical displacement. Can be percutaneously placed, unilateral, or bilateral.



Courtesy of Reza Firoozabadi, MD and Conor Kleweno, MD

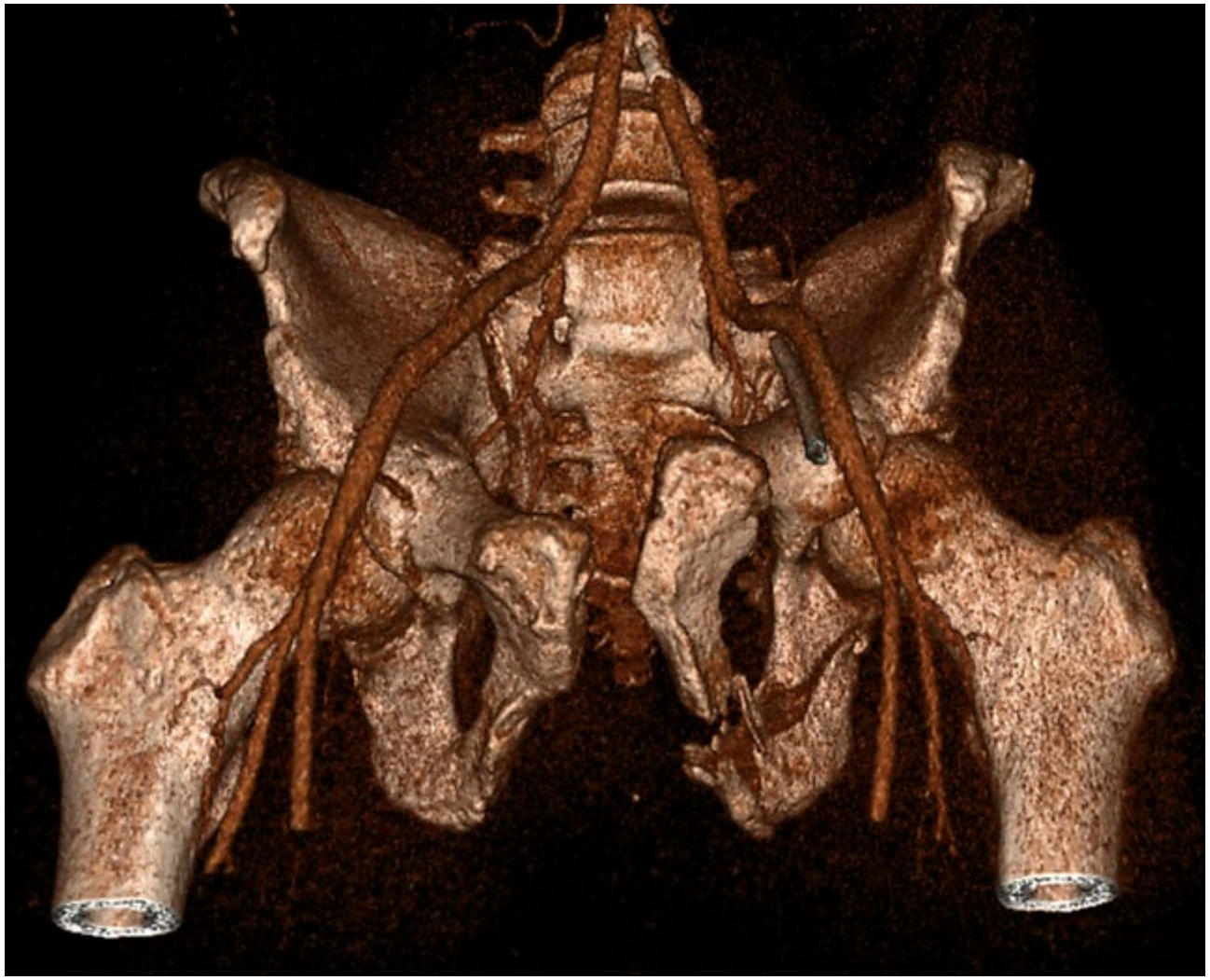
Posterior Pelvis Fixation Biomechanics

- Overall, biomechanical data lacks in comparison studies.

- Greater than 1 point of fixation (i.e. a single iliosacral screw) increases stability of an unstable posterior injury.
  - Ideally, multiple screws at multiple sacral segments will increase construct stiffness.

- Lumbopelvic fixation adds to posterior pelvic ring stiffness, especially with sacral comminution. A combination of an iliosacral screw and lumbopelvic fixation greatly increases construct strength.

Anterior Pelvis Reduction and Fixation



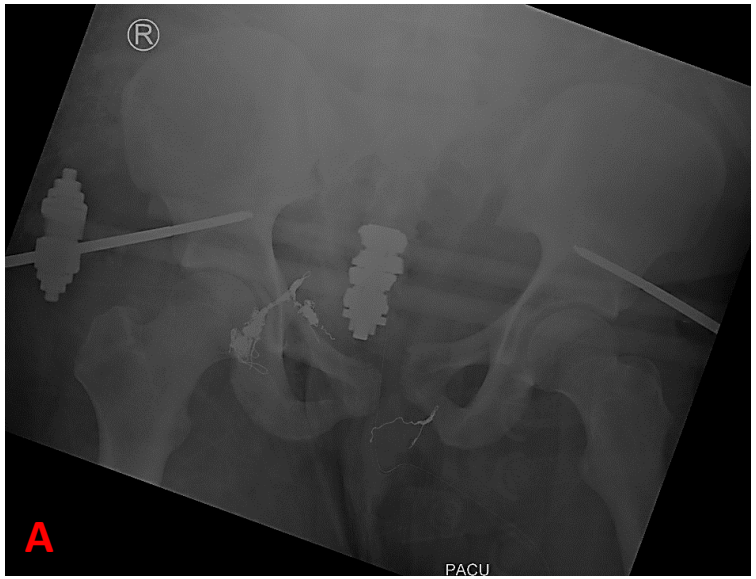
Treatment Options

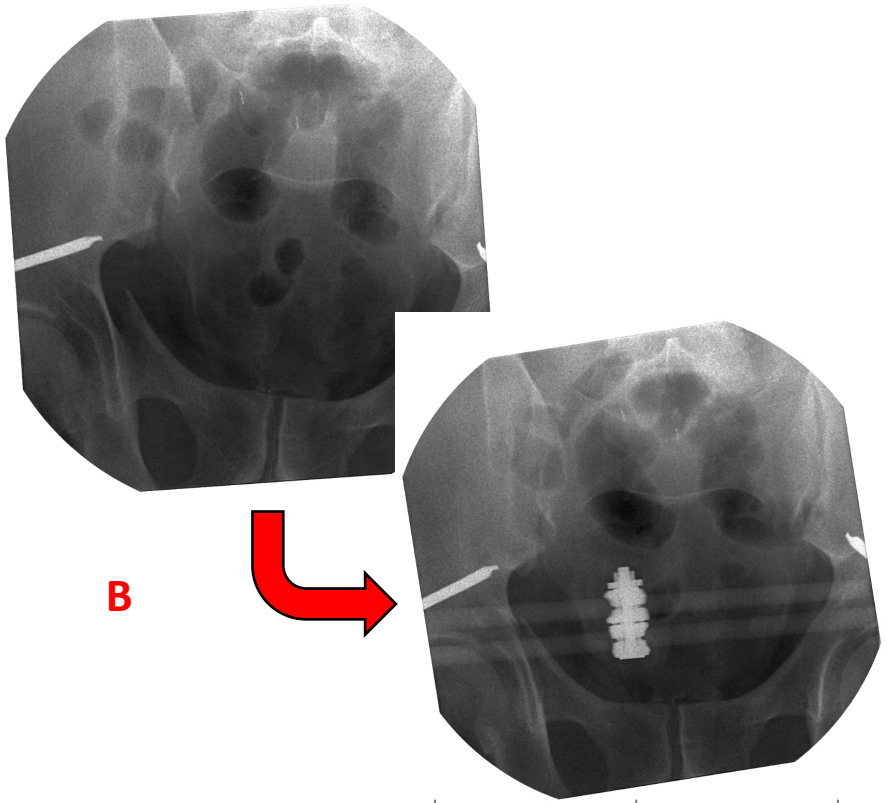
I. Posterior Ring
   i. Percutaneous sacroiliac screws
   ii. Percutaneous trans-iliac, trans-sacral screws
   iii. Percutaneous lumbopelvic fixation
   iv. Open sacroiliac joint plating
   v. Open sacral plating
   vi. Lumbopelvic fusion

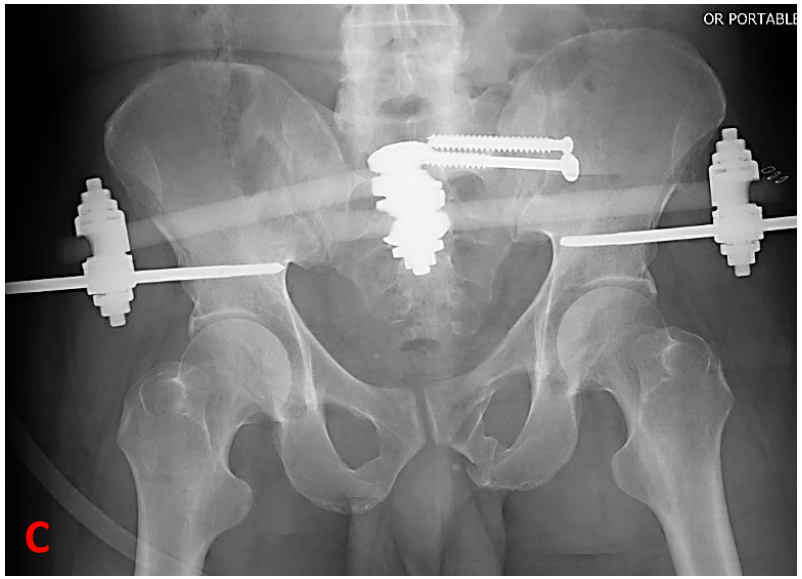
II. Anterior Ring
   i. External fixation
   ii. Internal-external fixation (Infix)
   iii. Percutaneous ramus screws
      a. Antegrade or retrograde
   iv. Open plating of pubic symphysis
   v. Open plating of pubic ramus

External fixation

- Applications:
  - Temporize a patient in extremis (**A**)
  - Provisionally reduce anterior and/or posterior pelvic ring (**B**)
  - Definitively treat anterior pelvic ring comminution (**C**)

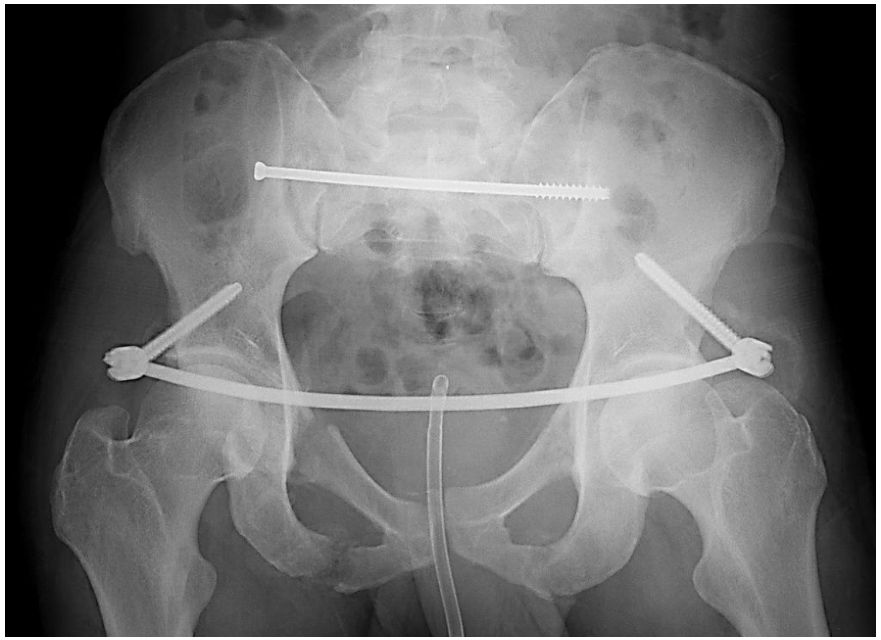


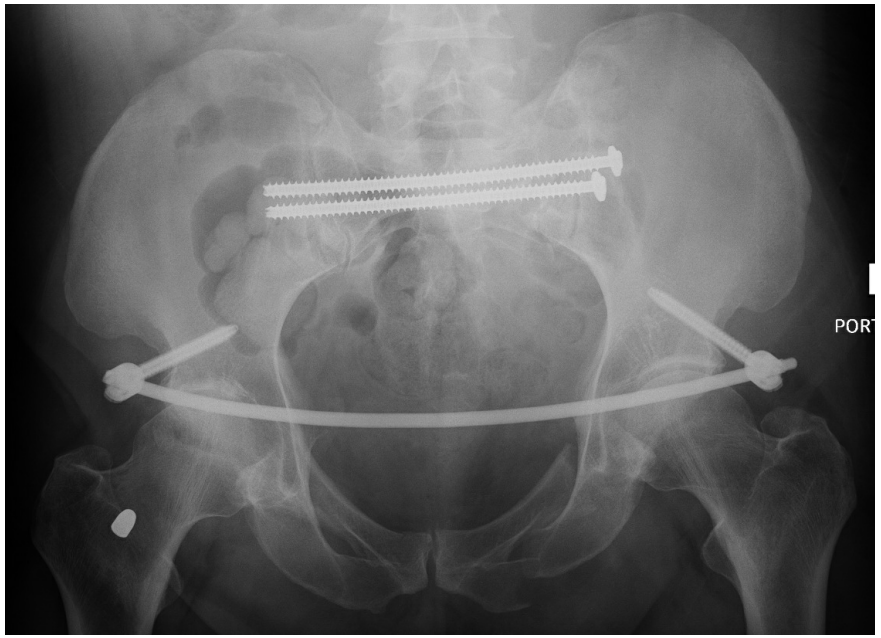




Subcutaneous fixator ("Infix")

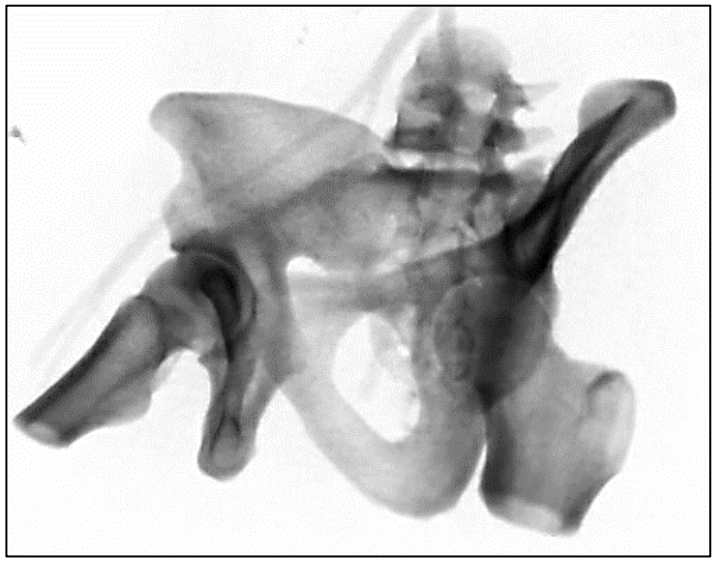
- Applications:
  - Long term definitive treatment of anterior pelvic ring
  - Decreases pin site infections seen in external fixators
  - Increased biomechanical strength compared to external fixator
  - Requires additional surgery to remove
  - May cause femoral nerve palsy if placed incorrectly





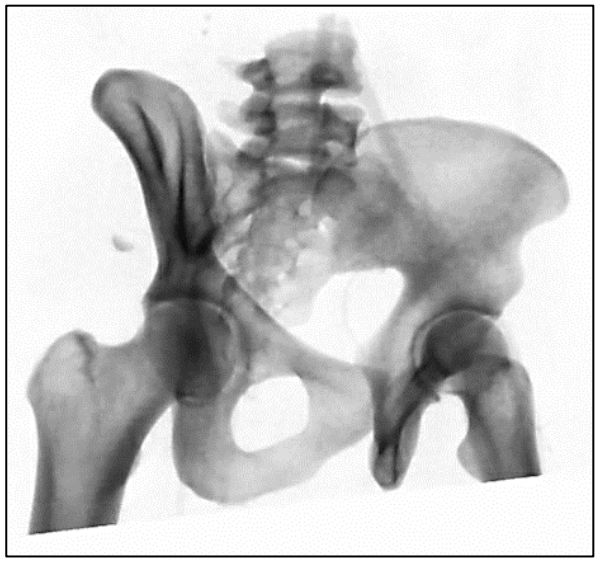
Courtesy of Thomas Moore Jr., MD

External fixation / Infix Radiographic views



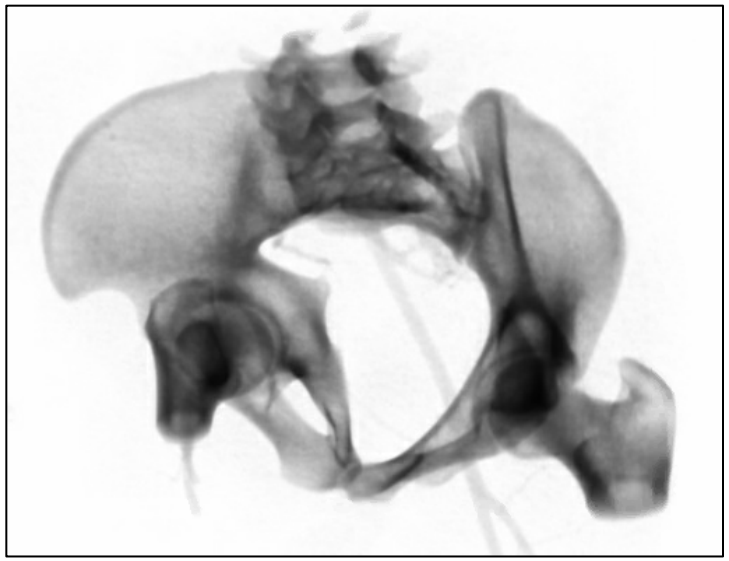
Combined outlet, obturator oblique

- Shows iliac “teardrop” – view down the osseous fixation pathway
- Use this view to place pin specifically into a portion of the pathway



Iliac oblique

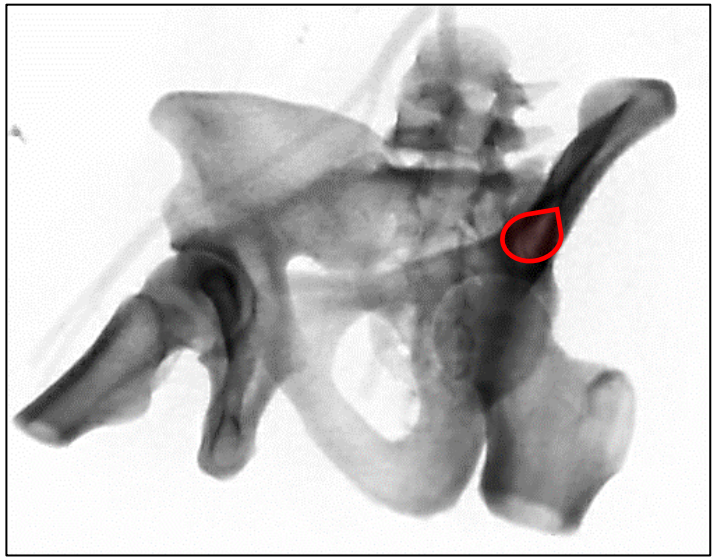
- Highlights the cranial and caudal trajectory of the fixator pin



Combined inlet, obturator oblique

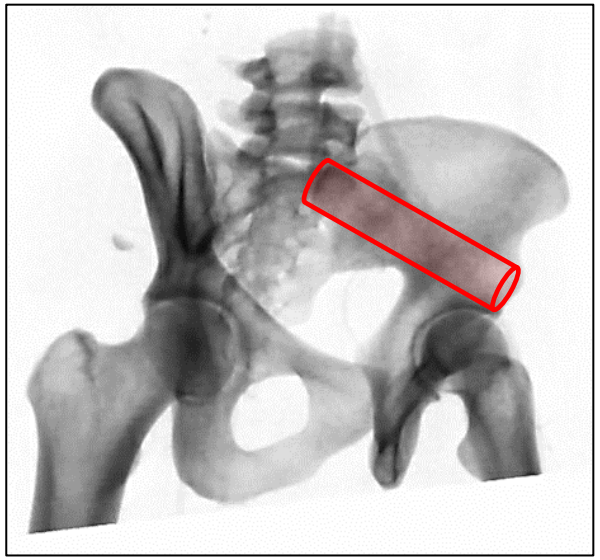
- Shows medial and lateral border of the osseous fixation pathway.
- If fixation is taken to the PSIS, a sacral lateral may be needed to ensure hardware is not proud posteriorly.

External fixation / Infix Radiographic views



Combined outlet, obturator oblique

- Shows iliac “teardrop” – view down the osseous fixation pathway
- Use this view to place pin specifically into a portion of the pathway



Iliac oblique

- Highlights the cranial and caudal trajectory of the fixator pin

Combined inlet, obturator oblique

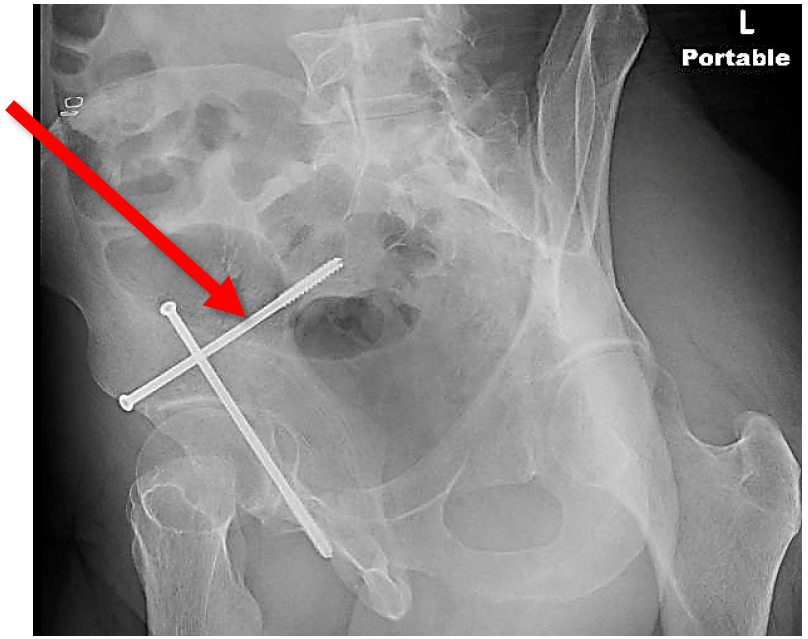
- Shows medial and lateral border of the osseous fixation pathway.
- If fixation is taken to the PSIS, a sacral lateral may be needed to ensure hardware is not proud posteriorly.

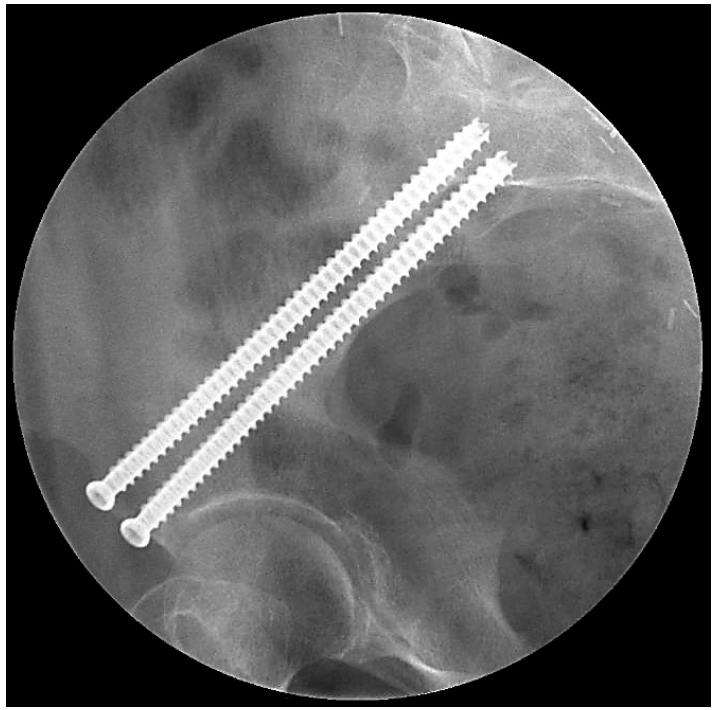
Ex-fix / Infix Technique Videos

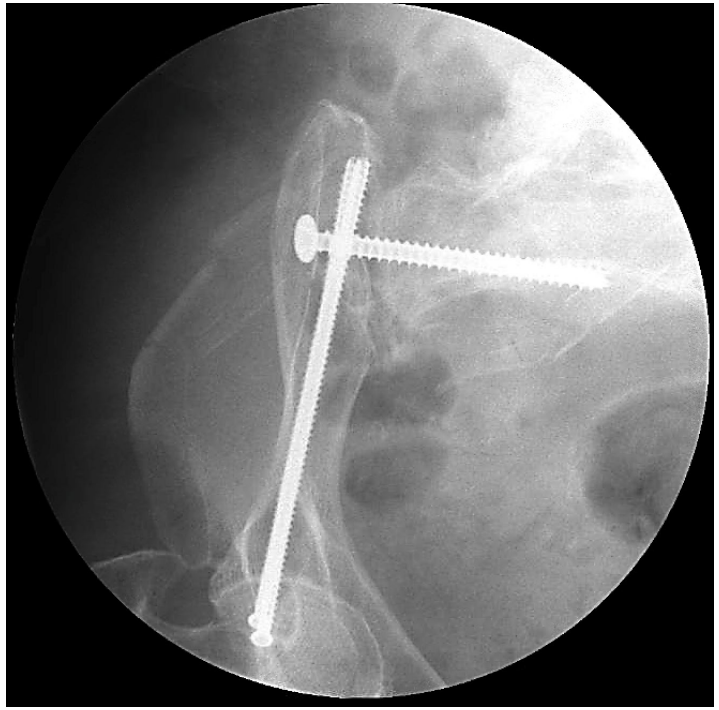
- External Fixator
  - https://otaonline.org/video-library/45036/procedures-and-techniques/multimedia/16731357/percutaneous-supra-acetabular-external-pelvic
- Infix
  - https://otaonline.org/video-library/45036/procedures-and-techniques/multimedia/16731359/the-anterior-pelvic-internal-fixator-infix

“LC2” Channel Screw

- Crescent fracture fixation may include a screw placed in the same corridor used by external / internal fixators.
- Osseous fixation pathway is often large enough to accommodate more than one screw if desired (*below right*).



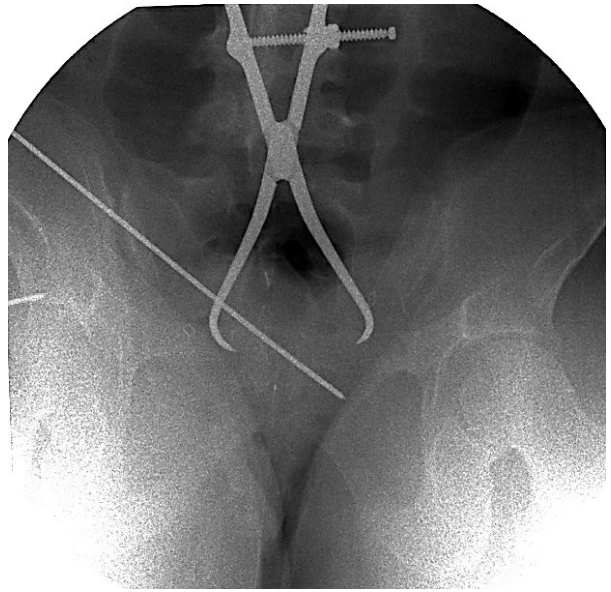


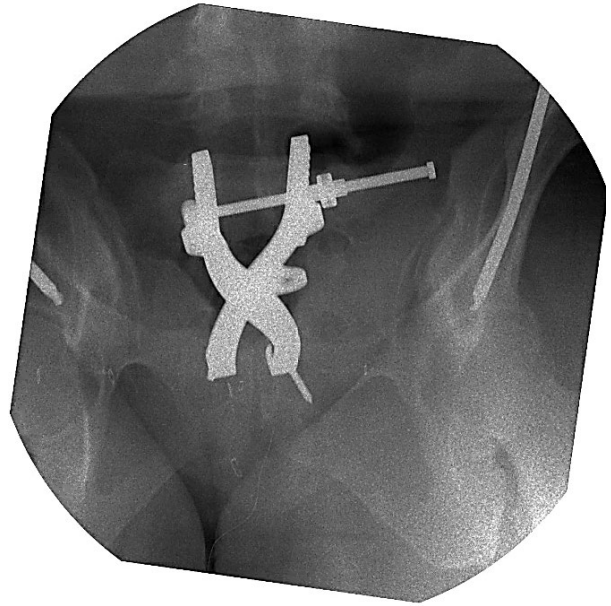


Courtesy of Reza Firoozabadi, MD

Pubic Symphysis Reduction

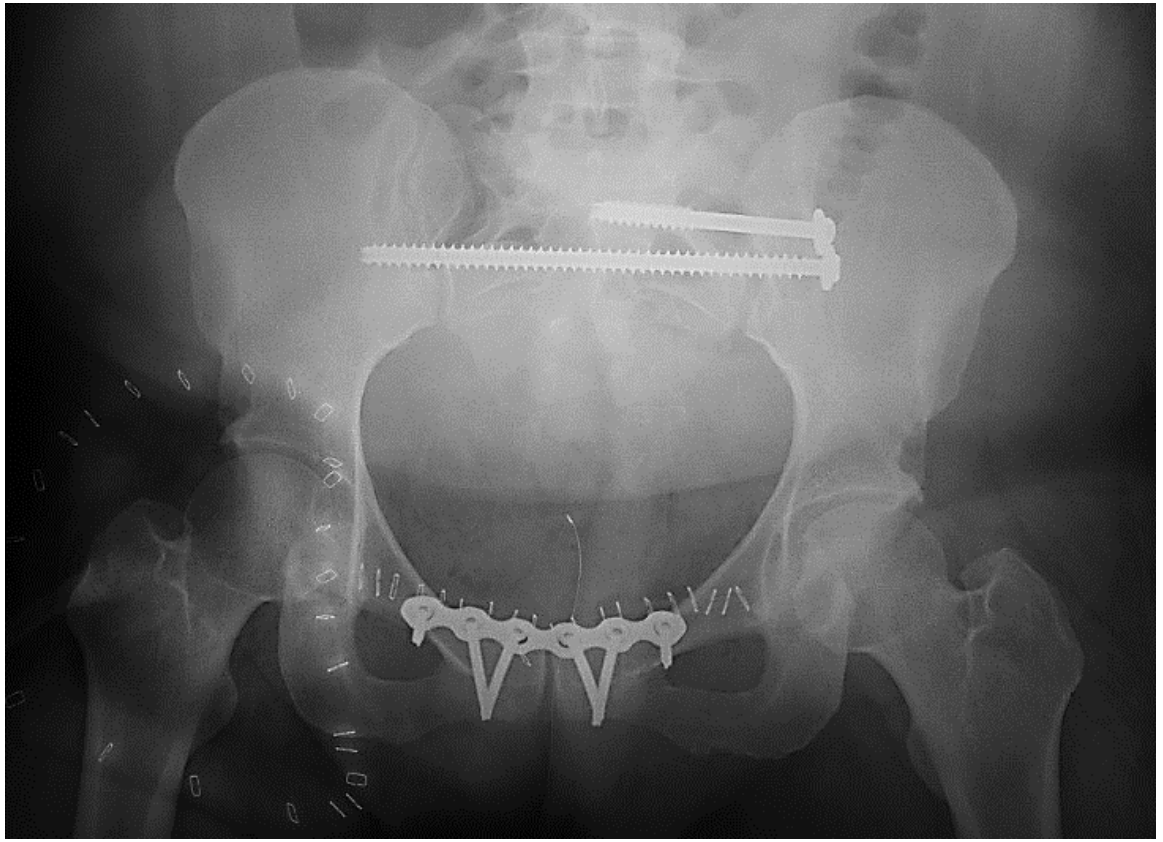
- Indicated when disruption of anterior symphysis results in instability
  - Historically, a disruption of greater than 2.5 cm indication for fixation
  - Imaging may not represent the true disruption (e.g. application of binder, interval reduction) at time of acute trauma
- Performed through Stoppa approach
- Weber clamp with tines upon each pubic tubercle
- Screw based clamp may be needed for difficult reductions





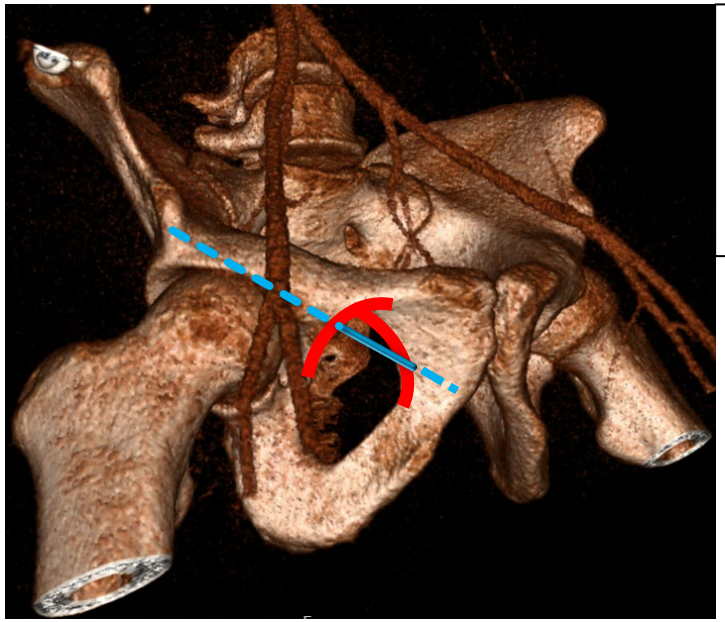
Pubic Symphysis Fixation

- Superior plate with > 2 screws on either side of the symphysis
- Anterior plate can be added to a superior plate for difficult reductions or revision surgery
- Indirect reduction with percutaneous fixation has been described



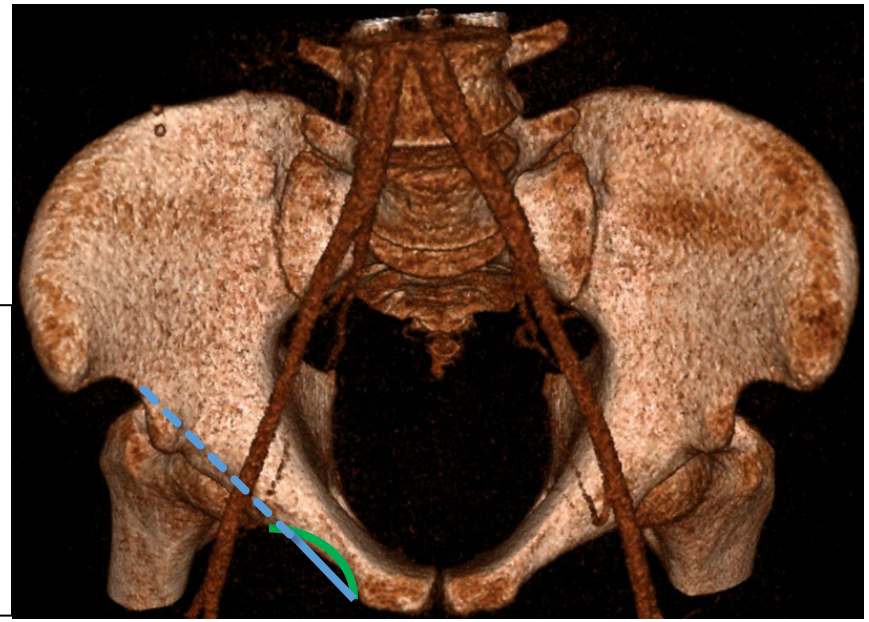
Percutaneous ramus screws

- The *anterior* and *inferior* superior pubic ramus bony morphology is undulating. This can lead to “in-out-in” screws if placed incorrectly.
- A safe position for a ramus screw is therefore **superior** and **posterior** within the ramus.



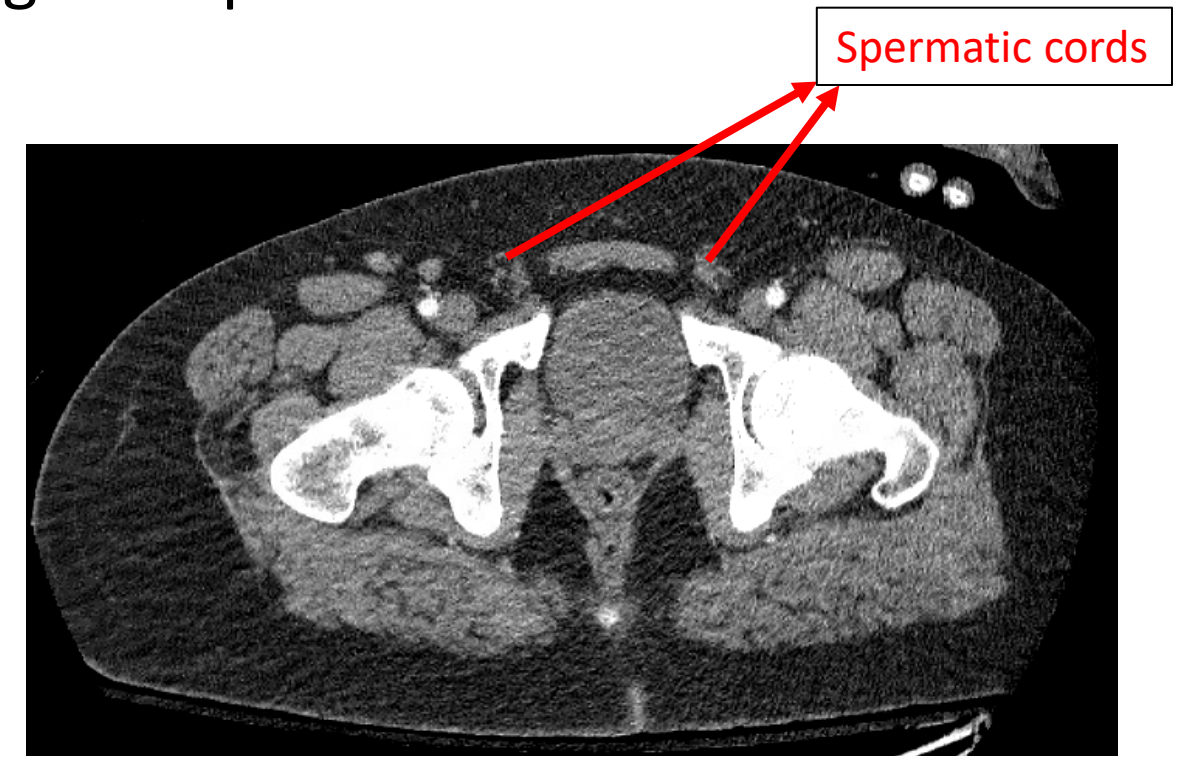
The red outlines the obturator sulcus. The blue line represents a screw placed too inferiorly, causing an in-out-in screw.

The green curve outlines the pectineal recess. The blue line represents a screw placed too anteriorly, causing an in-out-in screw.

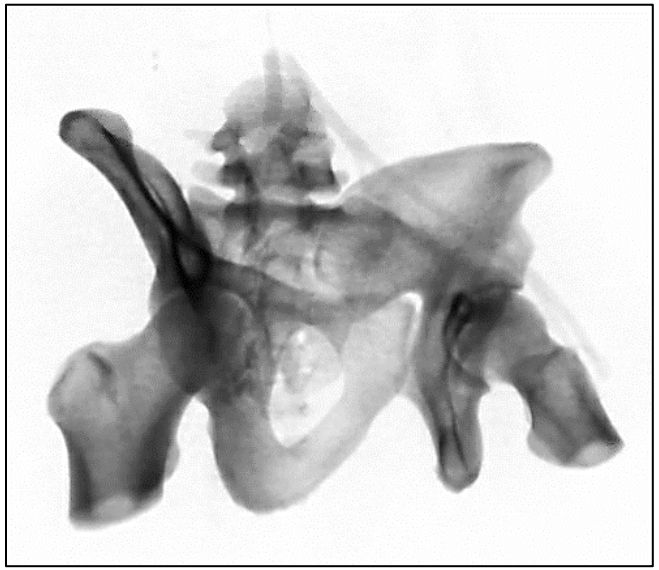


Retrograde Percutaneous Ramus Screw

- *Danger* The spermatic cord passes approximately 3cm lateral to midline – near the starting point for a retrograde ramus screw. Use caution in young male patients.

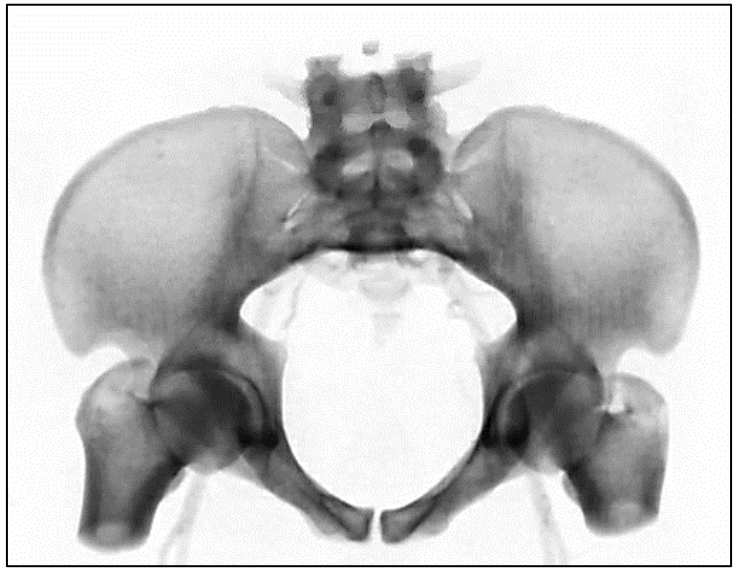


Percutaneous ramus screw radiographic views



Combined outlet, obturator oblique

- Allows visualization of the *cranial* and *caudal* borders of the osseous fixation pathway.



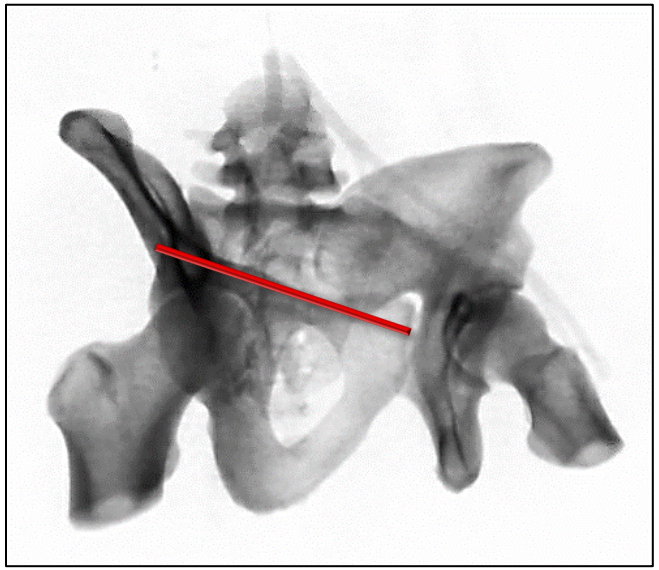
Inlet

- Allows visualization of the *anterior* and *posterior* borders of the osseous fixation pathway.

Combined inlet, iliac oblique

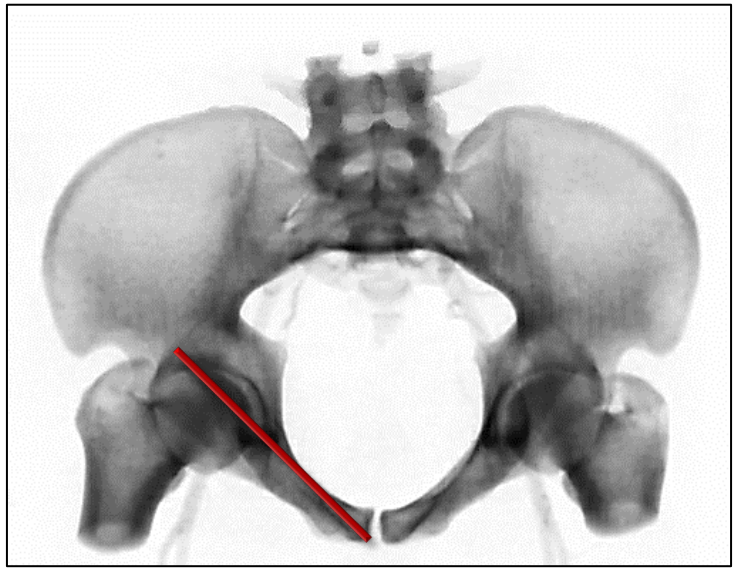
- Used as an alternative to the inlet to visualize the *anterior* and *posterior* borders of the ramus.

Percutaneous ramus screw radiographic views



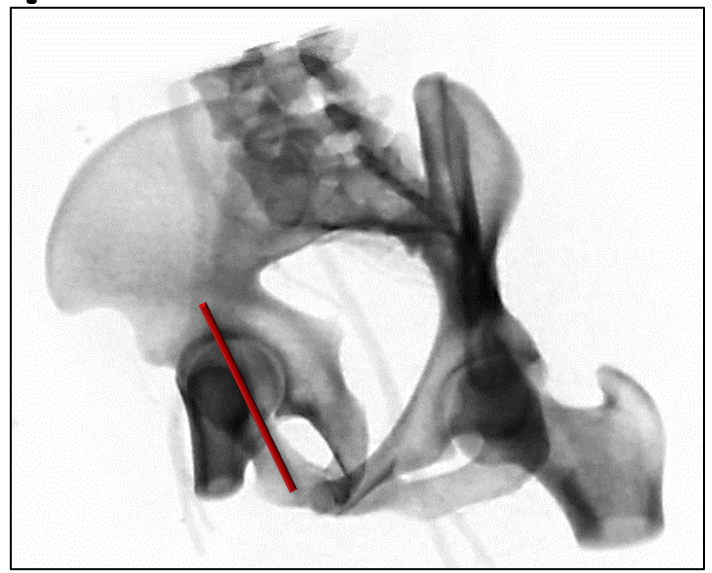
Combined outlet, obturator oblique

- Allows visualization of the *cranial* and *caudal* borders of the osseous fixation pathway.



Inlet

- Allows visualization of the *anterior* and *posterior* borders of the osseous fixation pathway.

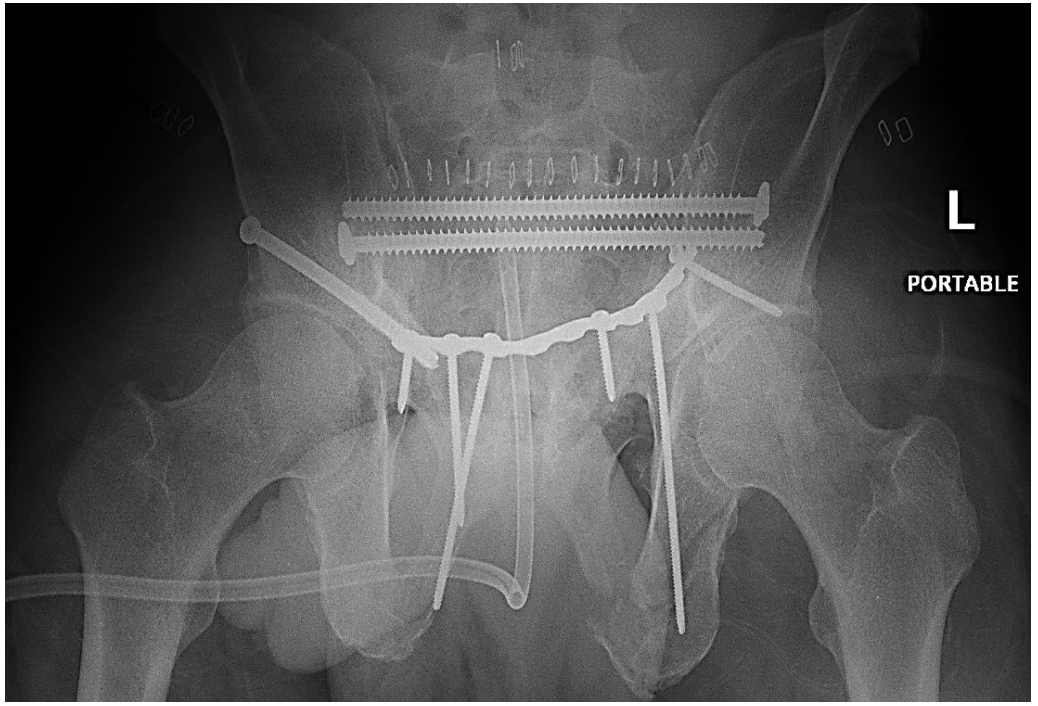


Combined inlet, iliac oblique

- Used as an alternative to the inlet to visualize the *anterior* and *posterior* borders of the ramus.

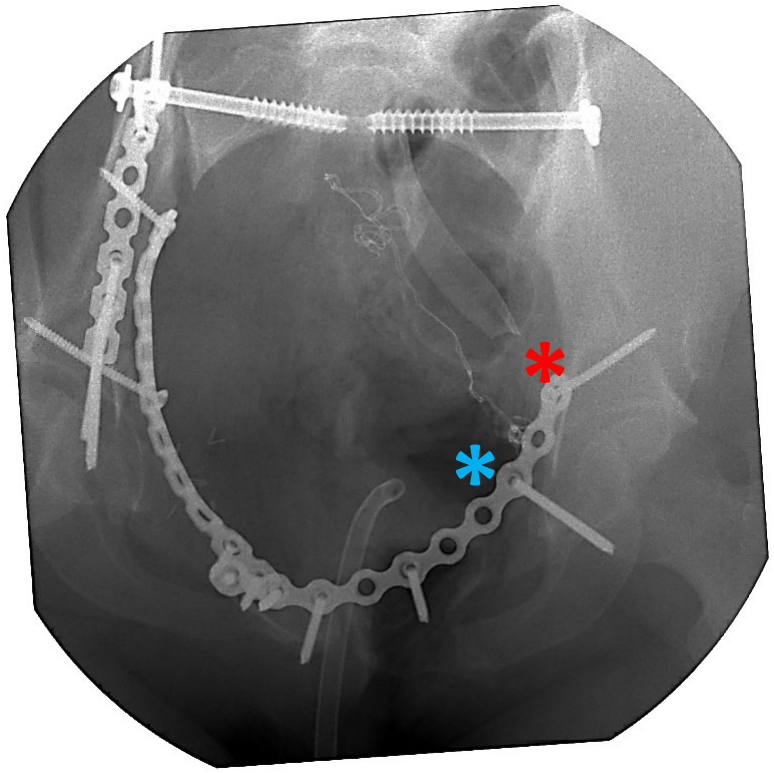
Anterior Pelvic Ring Plating

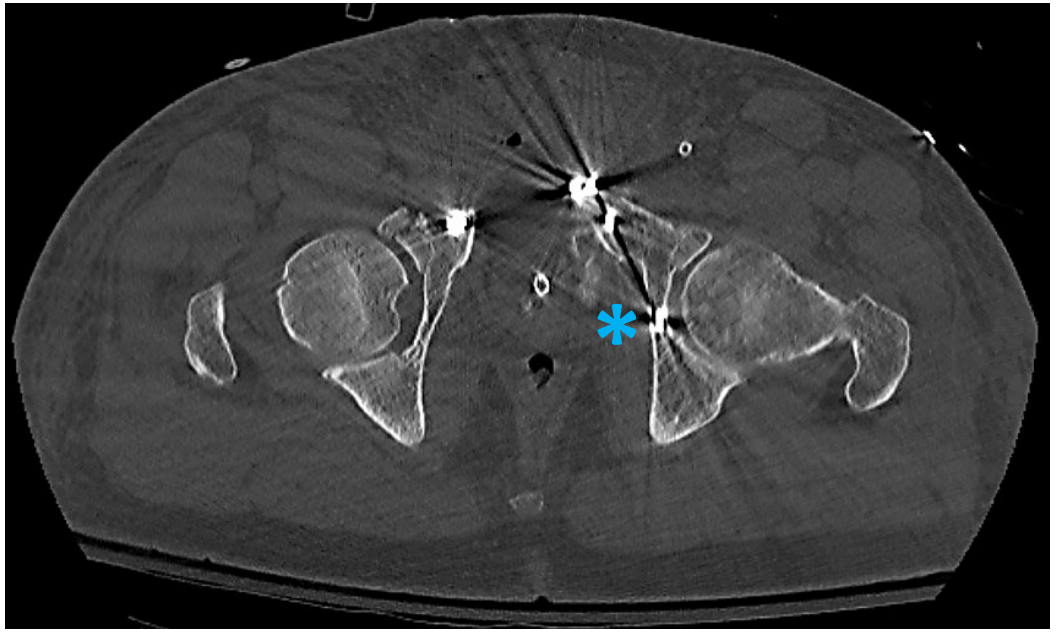
- Used for segmental or comminuted anterior ring injuries
- Considered when an external fixator or ramus screws aren’t ideal
- Careful plate contouring is essential



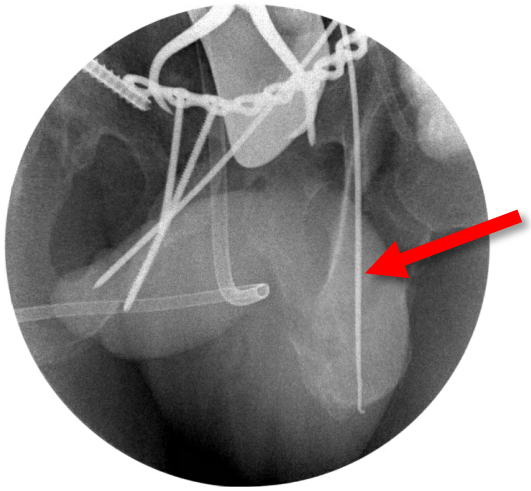
Anterior Pelvic Ring Plating

- Lateral plate is anchored with
  - Supra-acetabular cortical screws (*)
  - Quadrilateral surface screws (*)



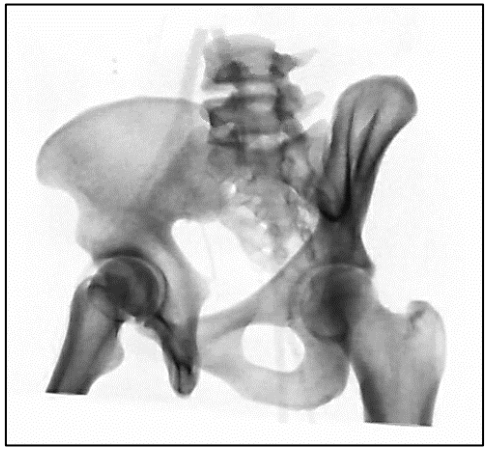


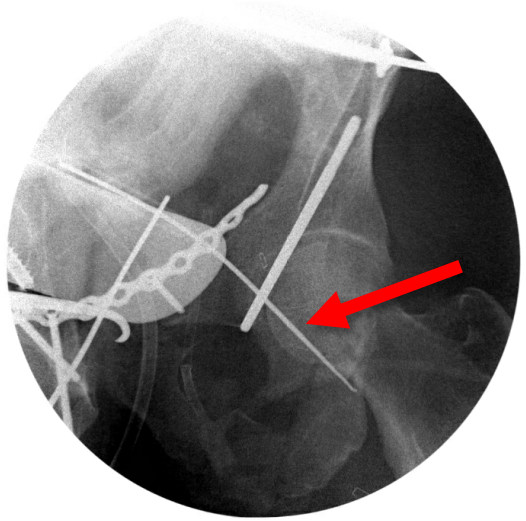
Quadrilateral surface screw radiographic views



Combined outlet, modified iliac oblique

- Iliac oblique is adjusted to view the quadrilateral surface at its thinnest point
- Allows visualization of the medial and lateral borders of the quadrilateral surface





Obturator oblique

- Used to determine the anterior and posterior extent of the fixation pathway
- Screw will end in the caudal ischium

Anterior Pelvis Fixation Biomechanics

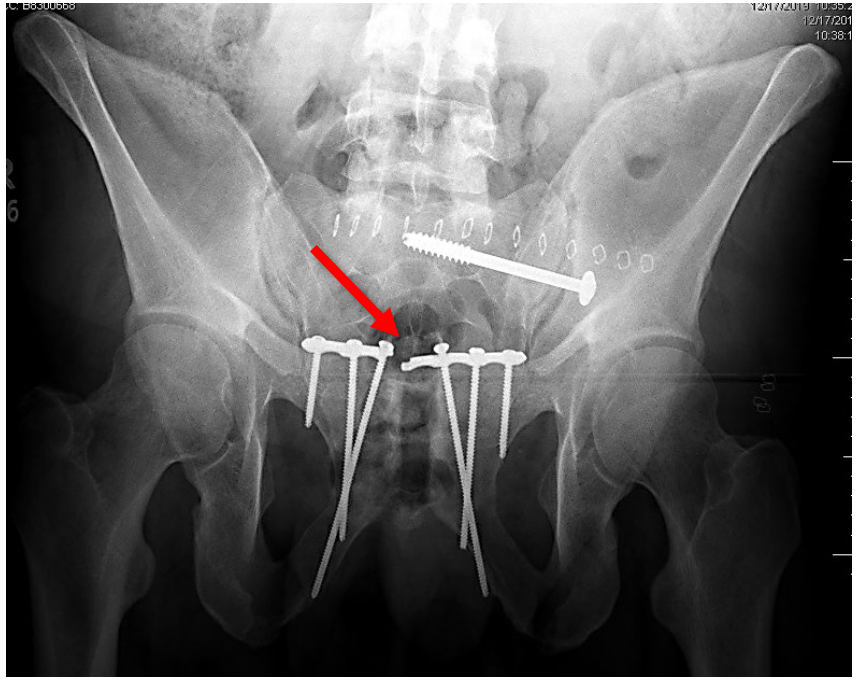
- Two screw construct for pubic symphysis plating is inferior to >2 screws.
- Anterior pelvic ring fixation can increase stability of the pelvic ring up to ~20%
- Retrograde pubic ramus screws have a higher incidence of failure than antegrade screws.
- Anterior based external fixator may provide some posterior compression, although not as much as a c-clamp or iliosacral screw.

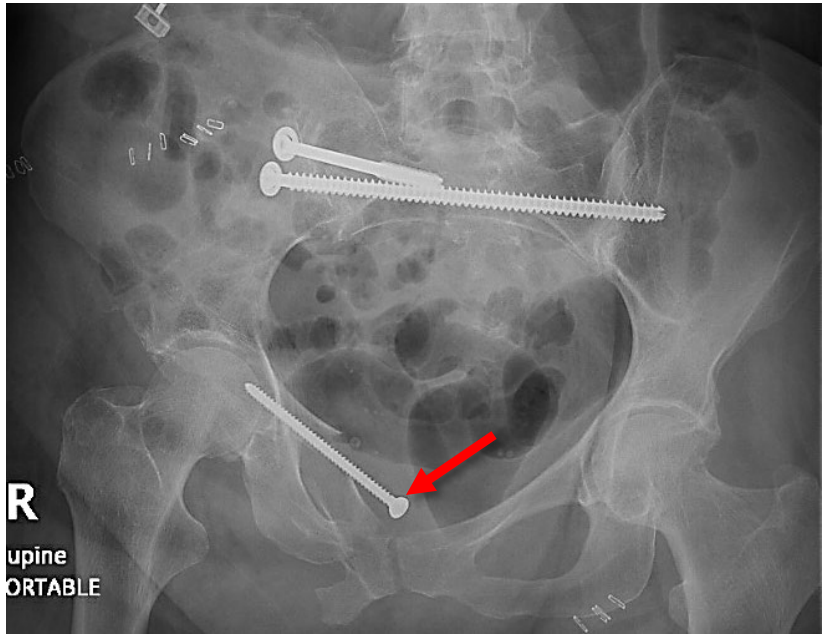
Pelvic Ring Injury Outcomes

- Mortality
  - 8.6 – 9.1%, largely due to associated injuries
  - Mortality and transfusion requirements increase with increasing Young-Burgess classification (i.e. an APC3 has a higher mortality and transfusion requirement than an APC2, etc.)
  - Lateral compression type fractures carry higher chest related injuries than anterior-posterior fractures.
  - Anterior-posterior injuries carry higher abdominal injuries than lateral compression injuries.

Anterior Pelvic Ring Outcomes

- Hardware failure with loss of reduction of the *anterior pelvic ring* can occur in 11-88% of cases.
- Examples include pubic symphysis plate breakage (figure above) and pullout of pubic ramus screws (figure below).
- Most patients do not require a revision surgery however.





Outcomes by Sex

Women

- Dyspareunia reported up to 56%
- Bladder rupture / lower extremity injury associated with worse outcomes.
- Hardware retention not found to preclude vaginal delivery, however a greater rate of women with prior pelvis fracture have cesarean deliveries.

Men

- Erectile dysfunction as high as 30%

Summary

- Thorough knowledge of normal, dysmorphic, and pathologic anatomy is critical for treating pelvic ring fractures.
- The patient's overall injury burden can often affect definitive management. Factors such as soft tissue envelope, prior embolization and prior abdominal/urologic surgery must be taken into account while pre-operatively planning.
- Surgical treatment options exist in a spectrum of invasiveness. Choose the least invasive technique that will achieve an accurate reduction.
- Ensure the posterior pelvic ring is well reduced. This will often require anterior pelvis fixation to "protect" the posterior ring.

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